Electrochemical Industry

VOL. I. NEW YORK, JULY 1, 1903. NO. 11.

Electrochemical Industry

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[*Incorporated.*]

114-118 LIBERTY STREET, NEW YORK.

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Telephone Call: 7607 Cortlandt.

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

ADVERTISING RATES GIVEN ON APPLICATION.

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Application made for Entry as Second-Class Matter at the New York Post-Office.

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HOW OTHERS SEE US.

In this issue we conclude our translation in abstract of the long report presented to the German Bunsen Society by Prof. F. Haber on electrochemistry in the United States. On his extended trip through this country last year, Dr. Haber has studied carefully and with open mind the methods of teaching chemistry and electrochemistry in various American universities and the development of industrial electrochemistry throughout this country. His report is one of the ablest and most complete papers which have been published on this subject, and is extremely suggestive on account of many remarks of a critical and general nature which Dr. Haber makes on the processes which he describes.

It is always of great interest to learn how others see us; and it is peculiarly interesting to read what a distinguished representative of the modern German scientific school of electrochemistry and physical chemistry has to say on the development of industrial electrochemistry in this country. The series of critical notes, contributed to our columns this month by various prominent American electrochemical engineers and scientists on special points in Dr. Haber's report, show that his report has been studied with great interest in this country. In such a young industry and science as ours it is impossible to expect uniformity of opinion concerning details of processes; and we hope to be able to continue in future issues the discussion of various questions which may be raised in connection with Dr. Haber's report. Probably the weakest point in the report is to be found in those few cases in which, as one of his critics puts it, Dr. Haber has practised the scientific use of the imagination to fill up gaps in his information; and it is greatly to be regretted that for commercial reasons we may be sure that just these points will never be criticised or corrected.

ELECTRODE POTENTIAL.

In this issue we publish an article by Mr. Woolsey McA. Johnson on the electrode potential or electrode voltage. The author has written this article with a special view of interesting practical electrochemical engineers and calling their attention to the important advantages which measurements of the electrode voltage have in practical electrolytic work. In fact, while the term electrode potential may have a somewhat novel sound to some practical men, yet measurements of the electrode potential are nothing new in certain classes of practical work; there is, for instance, probably no engineer of a storage battery concern who has not often made such measurements himself.

We may consider an electrolytic operation from the same point of view from which a business man looks at a business enterprise. We must start it in the right way, and we must

look out that the initial good conditions are maintained while the operation is going on. These nearly self-evident maxims represent, indeed, the complete solution of the problem of successful electrolytic operation. To take electroplating as a special example, it is first necessary to make up the electrolyte in the proper way; the plater must know exactly the composition of his solution, he must weigh the materials which he puts into the solution—this is just as necessary in an electroplating operation as bookkeeping is necessary to the merchant and business man. The second requirement for electroplating is that the plater knows at any time what is going on in his solution, that he keeps his solution in the good condition in which it was at the start.

In former issues of Electrochemical Industry we have already published several articles from prominent electrochemists who know exactly what they are talking about, and who all agree that it is the cornerstone of success in practical electrolysis, after operation has been started in the proper way, to watch that the initial good conditions are maintained. There is no secret about the tendency of the electric current to change an electrochemical system through which the current passes. Some of these changes which the current produces are just what is wanted; others we do not want, but they will inevitably take place, and it is necessary to do something in order to counteract them.

Dr. F. Haber, in his report published in this issue, goes so far as to say that often electrochemical processes, after having proven successful in the laboratory, have failed on an industrial scale for the simple reason that the experimenter in the laboratory worked with pure materials, and that in continuous industrial operation the solutions soon became impure. Dr. Haber says you can accomplish anything with pure solutions, nothing with foul solutions. It is significant that such a successful practical electrochemist as Mr. D. H. Browne concurs absolutely in this opinion of Dr. Haber's, as will be seen from some notes of Mr. Browne, also published in this issue. Indeed, theory and practice must lead to the same results, if both are on the right way; in many cases practical men and theoretical men have been equally sinners; on the one side there is too much tendency to follow the rule of thumb and to go easy, on the other side there is too much exact mathematics and not enough common sense.

How is it possible to know what is going on in a solution during electrolysis? All the physical and chemical methods of testing are at our disposition. One of the simplest and most important instruments in this connection, however, is the voltmeter; while it primarily gives the volts at the terminals of the cell, it indirectly indicates the power which is consumed. To obtain a required number of pounds of a certain substance, by electrolysis, it is necessary to pass a certain number of ampere-hours through the cell, and as this number follows from Faraday's law, it cannot be diminished by artificial means or by inventive skill; nature requires a certain number of ampere-hours to give a certain output in pounds. But the lower the voltage at which these coulombs are passed through the cell, the smaller is the energy consumed, and it is this energy which costs money, and which is one of the most important items in the cost sheet of electrochemical operations.

A voltmeter across the terminals of an electrolytic cell thus indicates the total energy consumed in the cell, and a voltmeter across the terminals of a storage battery, discharged at constant current, indicates the energy given out by the battery. Now, in the latter case, the electrochemical process at the electrodes consists in the change of lead peroxide into lead sulphate at the anode. When either the anode or the cathode has been fully changed into lead sulphate, the action stops and the battery cannot give out any more energy; the e. m. f., as indicated by the voltmeter across the terminals, drops suddenly.

It is, however, evident that this failure of the battery may be due either to the anode or the cathode having been completely changed into sulphate. The voltage across the terminals of the battery does not indicate whether the anode or the cathode has given out; but it is important to know which one is exhausted, because for practical reasons both the anode and cathode should have equal capacity and should become exhausted at the same time. It is for this reason that practical storage battery engineers determine the e. m. f. of each plate separately against a third auxiliary electrode; in other words, they determine the "electrode potential" of each plate.

A third auxiliary electrode—the potential of which against the solution is well defined—may, of course, be applied to watch the process going on in any electrolytic cell. If, after having started an electrolytic constant current operation, we find that the e. m. f. quickly rises (meaning a sudden increase of the energy consumed), then the measurement of the electrode potential of each electrode separately tells us at which plate an important change of the conditions has taken place, so that we may act accordingly. We are thus more exactly informed concerning what is going on in the cell than by simply measuring the e. m. f. at the terminals of the cell.

FIFTH INTERNATIONAL CONGRESS FOR APPLIED CHEMISTRY

The Fifth International Congress for Applied Chemistry has just been held at Berlin, and, according to the preliminary reports received by us, it turned out to be an equally important and enjoyable affair. The attendance was greater than at any previous international congress of chemists, the number of members being above 2600. We regret that, owing to delays in the mail, we did not receive the complete report of the proceedings in time to publish it in this issue, but may give here a preliminary summary of the work of the Congress as a whole, and of that section which is of special interest to our readers, *i. e.*, section X., devoted to electrachemistry and physical chemistry.

There were three general meetings, in which all the members of the congress participated. The first was taken up by the numerous speeches of welcome; the second was devoted to the reading of papers of general interest by authors of international fame; at the third general meeting a number of resolutions were voted on concerning the standardization of certain analyses and concerning uniformity of chemical nomen-

clature. A list of the most important units of physical chemistry and electrochemistry—nearly throughout agreeing with the usual German notation—was proposed and submitted to the German Bunsen Society, in order to suggest amendments to the standing committee of the International Congress.

The authors of papers, read before the second general meeting of the Congress, represented various countries, none, however, being from the United States. The speakers were Prof. Henry Moissan, of Paris; Sir William Crookes, of London; Prof. J. H. Van't Hoff, of Berlin; Mr. Ernest Solvay, of Brussels; Prof. C. Engler, of Karlsruhe, and Prof. G. Kraemer, of Berlin. Prof. Henry Moissan read the first paper, on metallic hydrides; he gave a review of the work of Wurtz, Winkler, Guntz and himself in preparing the various hydrides of metals and described their properties; from the fact that they are non-conductors of electricity, he concludes that hydrogen has no metallic character.

Sir William Crookes, of London, followed with a highly interesting lecture on modern views on matter—the realizations of a dream. He mentioned that in 1809 Sir Humphry Davy already spoke of "radiant matter"—although in a sense somewhat different from that in which it is now used—and that he foresaw the modern science of radiation and the theory of electrons, in his statement that if particles of gases were made to move in free space with an almost infinite velocity, *i. e.*, to become radiant matter, they might produce the different species of rays so distinguished by their peculiar effects. Some prophetic statements of Faraday were also quoted. In 1879 Crookes himself advanced the theory that in the phenomena of the vacuum tube at high exhaustion the particles constituting the cathode stream consist of fragments of matter, ultra-atomic corpuscles, minute things, very much smaller, very much lighter than atoms, things which appear to be the foundation stones of which atoms are composed. Thus, we actually reach the borderland of science—where matter and force seem to merge into one another. Sir William sketched the development of the electron theory in recent years, and pointed out its enormous scientific importance, but at the same time he reminded his hearers that it must never be forgotten that theories are only useful as long as they admit of the harmonious correlations of facts into a reasonable system. Prof. J. H. Van't Hoff spoke on the formation of the salt beds, found in nature, his conclusions being based on his own investigations of the Stassfurt salts. Mr. Ernest Solvay gave some historical notes on his well-known soda process. Prof. C. Engler gave a review of the problem of autoxidation, and Prof. G. Kraemer gave a summary of the development of the tar industries.

The main work of the Congress was done in eleven sections, the tenth of which was devoted to electrochemistry and physical chemistry. The annual convention of the German Bunsen Society was combined with the meetings of this section. A great number of papers were presented. J. Traube explained his views on the conditions of gases and fluids; he assumes that fluids contain two kinds of molecules which he calls fluidons and gaseons, while gases contain only the latter. Tammann, in the discussion, did not consider the experiments described by the author to be decisive for the correctness of his theory. Prof. W. Nernst described his apparatus for determining vapor densities at very high temperatures, known to our readers by the author's paper read on the same subject at the recent New York meeting of the American Electrochemical Society. Froelich described a new form of a resistance furnace, Wedekind spoke on colloidal zirconium and Marie on electrolytic reduction. Two extensive reports were presented by Foerster and Brandeis on the industrial application of electrolytic methods to the preparation of inorganic compounds.

LeBlanc gave an account of an investigation of electrolysis by alternating currents; that electrodecomposition takes place is due to the fact that the processes at the electrodes are not exactly reversible. For instance, when the current flows in one direction, metal is deposited, and when the current is then reversed, the metal is not redissolved, but, perhaps, something else; it seems possible to use such experiments to draw conclusions on the speed of ionic reactions. Lebeau spoke on electrometallurgical products, Gin on the manufacture of aluminium, and Coehn on the influence of the material of which the electrodes consist, on the process of electrolytic oxidation and reduction; two different influences must here be distinguished: the over-voltage, which is different at different materials, and catalytic influences on the reaction. Goldschmidt gave a review of the various electric iron and steel processes which have been tried on a large experimental scale, and Mr. Edw. R. Taylor, of Penn Yan, N. Y., presented a paper on his process of making bisulphide of carbon in the electric furnace. Kuester read a paper on the dissociation pressure, and Guntz on the preparation of barium. Schenck presented the results of his experiments on the decomposition of carbon monoxide into carbon and carbon dioxide in contact with platinum asbestos, and Bodenstein and Bodlaender read two papers on the speed of formation of sulphuric oxide from sulphurous oxide and oxygen in contact with platinum wire. Zengelis spoke on chemical reactions at very high temperatures, Goldschmidt on the kinetics of reduction phenomena, and various elaborate reports were presented by Elbs and Buchner on electrolytic methods for preparing organic compounds, by Bodlaender on applications of catalytic action on various problems of organic and inorganic chemistry, Sackur on the installation of electroplating plants for plating great quantities of small objects, Danneel on quantitative separation and deposition of metals by electrolysis.

While for details we must refer our readers to the full report which will be published in our next issue, the above brief sketch of the work of the electrochemical section alone, together with the enormous number of members inscribed, proves that the Congress has been a gratifying success. The benefits of a reunion of chemists from all countries of the world are not alone social. Although the general principles of chemistry are the common property of chemists in all countries, yet the differences existing in the different countries in political, commercial and social respect, have caused chemical industries to develop on different lines in different countries. An international congress offers to chemists an opportunity to learn to understand and appreciate the difficulties and problems which their professional brethren have to face in other countries.

INTERNATIONAL CONGRESS FOR APPLIED CHEMISTRY.

The Fifth International Congress for Applied Chemistry was formally opened on June 3. Prof. O. N. Witt presided, and a great many leading authorities on chemistry from all parts of the world were present. Speeches of welcome were delivered by Count Posadowsky, Imperial Secretary of State for the Interior, and Dr. Studt, Prussian Minister of Education. Among the foreign delegates who delivered addresses were Prof. Moissan, of Paris; Prof. Tilden, of London; Prof. Ludwig, of Vienna, and Prof. Clarke, of Washington.

About 2,600 members were present, and there were 350 papers and reports on the programme. The Congress was divided into eleven sections and three sub-sections, section X being devoted to electrochemistry and physical chemistry. The German Bunsen Society also held its annual meeting at Berlin during the same week, and took charge of the electrochemical section. An editorial comment on the work of the Congress is found on another page.

AMERICAN ELECTROCHEMICAL SOCIETY.

At the Board Meeting of the American Electrochemical Society, held at Philadelphia on June 13, the following gentlemen were elected members of the Society: F. E. Drake, New York; I. J. Moltkehansen, Perth Amboy, N. J.; F. T. Snyder, Oak Park, Ill.; Dr. H. Reisenegger, Augsberg, Germany; Robert Spice, New York; Dr. Leo Boekelard, Berlin, Germany; H. Wigglesworth, New York; H. J. Lucke, Washington, D. C.; S. W. Traylor, New York; Dr. Paul Askenasy, Nuremberg, Germany; Dr. Rudolph F. Gahl, Philadelphia, Pa.; N. B. Cornwall, Princeton, N. J.; B. F. Thomas, Chattanooga, Tenn.; H. A. Jackson, New York; C. E. Speirs, New York. The fall meeting of the Society is to be held at Niagara Falls, from Sept. 17 to 19.

FIRST ANNUAL REPORT OF THE INTERNATIONAL NICKEL COMPANY.

The first annual report of the International Nickel Co. (which owns the Canadian Copper Co., the Orford Copper Co., the American Nickel Works in the United States, the Nickel Corporation, Ltd., the Société Minière Caledonienne in New Caledonia, a large interest in the Société Le Nickel, etc.,) covers the year ending March 31, 1903. The profit account shows earnings of constituent companies, less selling and administrative expenses, $1,090,401; interest, $29,016; total, $1,119,417. On the other hand, the general expenses were $110,024; the interest on bonded debt, $450,244; total, $560,268; so that the surplus for the year amount to $559,149. The accounts of the New Caledonia companies were not received in time to be included in the above account.

The directors' report states that a careful examination of the various manufacturing plants has shown them to be in very bad condition, nearly all the machinery being very old and much of it obsolete, expensive to maintain and operate. Expenditure for repairs on the Canadian, the Orford and the American Nickel Works was $225,435 during the year; this is excessive and should eventually be largely reduced. The intention is to reconstruct the plants of the constituent companies, bringing them up to the highest standing of metallurgical and economical efficiency. During the past year only such improvements have been made as were absolutely necessary to keep these plants in successful operation and produce the required amount of metals, the changes made being such as would fall within the general scheme of reconstruction.

At the Ontario works of the Canadian Copper Co. a third Browne calcining furnace of larger capacity than the two furnaces there in operation has been installed. The older furnaces have been increased to 40 feet in length, a cooling device, conveyors and a briquetting plant to handle mechanically the product of 12 calcining furnaces, are now being installed. These improvements, now nearly completed, will double the capacity of the plant and materially reduce the cost of treatment per ton.

At the Orford Copper Co.'s works a new nickel refinery has been erected to provide the increased quantity of nickel required as metallic nickel, and to reduce the cost of refining; the old nickel refinery has been abandoned.

A new smelting plant is built at the Orford Copper Co.'s works in Canada. The new works will be equipped with the best and most economical steam and power plants, blast furnaces, ore and matte handling devices, together with new locomotives and proper cars for handling the ore to the furnaces. The cost of this plant is estimated at $500,000, and the estimated saving is $200,000 to $250,000 a year. It is expected that the new plant will be in operation within one year from the present time. When this improvement is completed the Orford Copper Co.'s works will be reconstructed on modern lines, thereby effecting a very large saving.

Efforts are being made to introduce nickel into new fields and to extend its use in old lines, particularly to extend the use of nickel-steel. The results have already been very gratifying; about 12,000 tons of steel rails, 3.25 per cent. nickel, have been purchased by the American railways, and are nearly all manufactured. Seamless drawn tubes, containing a high percentage of nickel, have been successfully manufactured, and an important market is expected for these tubes. It is also probable that within a very short time nickel-steel will be largely used in bridge construction.

In connection with this official report, it will be of interest to read the remarks of Dr. F. Haber on the nickel industry in general, and particularly on the Browne process, published on another page of this issue.

Liebig Celebration.—A large number of members of the American Chemical Society, the American Electrochemical Society, the Chemists' Club, and the New York Section of the Verein Deutscher Chemiker participated in the centennial celebration of the birthday of Justus von Liebig, held in the assembly hall of the Chemists' Club in New York City on May 12. Dr. Ira Remsen, of Johns Hopkins, delivered the first address, in which he gave an outline of the life and work of Liebig and recorded some personal reminiscences of the time when he attended Liebig's lectures at Munich; Liebig used to illustrate his lectures by extremely elaborate experiments, and was always fond of dramatic effects, a most effective experiment being usually reserved for the conclusion of the lecture. The second address was delivered by Prof. William H. Brewer, of Yale, who is the oldest living pupil of Liebig in the United States. His address was full of personal reminiscences; he had read in 1846 Liebig's book on agricultural chemistry, and in his desire to study under him he came to Munich. The late Ogden Rood (afterward professor at Columbia) advised him that it was extremely difficult to get admission to Liebig's laboratory as a student; he advised him not to use his letters of introduction, not to call Liebig "Herr Professor," but "Herr Baron," and not to spare flattery. Brewer, when introduced to Liebig, followed this advice, but Liebig told him he would better go somewhere else, as he could give him no attention whatever. Brewer finally said that he came three thousand miles to sit at the feet of the greatest teacher of chemistry in Europe, and that he had come to stay there. Then he was admitted to the laboratory, where he remained for a year, but received practically no attention from Liebig, just as the latter had promised. The last speaker was Dr. Carl Duisberg, director of the Elberfeld Color Works, who spoke on Liebig's influence on chemical industry. It is to be placed mainly to Liebig's credit that scientific chemical investigation displaced the rule-of-thumb in all the great chemical industries of Germany, and to some extent his influence was also felt in other countries. His influence was greatest, however, on organic chemical industries.

OONATIOFNTHE OXIDSILOXICON.

By EDWARD G. ACHESON.

The descriptions of the new refractory substance, siloxicon, that have recently appeared in the technical press and in the newspapers have created such a widespread interest, as evidenced by the numerous inquiries received from all parts of the country and all lines of industry, that it is desirable to correct a statement that was contained in these publications.

It was there stated that siloxicon was inoxidizable, but recent investigations have shown that this is not true. When it is heated to, or above, 2674° F. in an atmosphere containing a large amount of free oxygen decomposition occurs.

Siloxicon, while variable in composition, may be represented by the formula Si_2C_2O, and when heated, as above stated, in presence of free oxygen, decomposition takes place, probably in accordance with the following equation:

$$Si_2C_2O + 7O = 2SiO_2 + 2CO_2.$$

If the siloxicon be in the form of a brick or other molded mass the reaction occurs on the surface, producing a vitreous glaze, which in most instances is tinged light green from the presence of iron.

In the absence of free oxygen or in a reducing atmosphere no such decomposition occurs, and the temperature may be raised to the point of the formation of carborundum, or, approximately 5000° F., before any change occurs, and then it takes place, it is thought, in accordance with this equation:

$$Si_2C_2O = SiC + Si + CO,$$

solid carborundum remaining, while the vapors of silicon and carbon monoxide are given off.

It is interesting to note that after having discovered this oxidation of siloxicon, tests were made with carborundum, and it was found to be affected in a manner exactly similar to siloxicon; this notwithstanding the fact that for more than twelve years it had been generally considered inoxidizable.

ELECTRODE VOLTAGE OR ELECTRODE POTENTIAL.

By WOOLSEY MCA. JOHNSON.

The ELECTROCHEMICAL INDUSTRY has received so many enquiries as to the term "electrode-voltage" and "electrode-potential," used in previous articles by me, that it is thought that a short paper explaining this term will be not without interest to its readers, or at least to those readers engaged in practical work in the electrolytic deposition of metals.

The phenomena of electrolytic dissolution, electrolytic conduction, and electrolytic deposition, simple as they seem to those of us who see the concrete facts daily, are really of the deepest nature and underlie many complex facts. When we know more of the mechanism by which these simple changes are affected, then we will know better the relation between electricity and matter. Any digression into the realms of the "electron" theory is outside of the bounds of this article, which is a review of our present experimental knowledge of electrolytic action at the cathode and electrolytic action at the anode, combined with some explanations of the experimental facts.

Let us consider a cube of one centimeter dimension made by two platinum electrodes dipping in a 5 per cent. solution of sulphuric acid. This has a resistance of about five ohms at room temperature. If the laws of metallic conduction held, on impressing a voltage of 0.50 volts a current of 0.10 ampere would flow through the circuit, and on doubling the voltage the current would double. Thus the curve of the relation between voltage and current would be absolutely a straight line, as is demanded by the simple relation known as Ohm's law.

$$\text{Amperes} = \frac{\text{volts}}{\text{ohms}} \quad \text{(see Fig. I.)}.$$

Now, no such curve, as found for the laws of metallic conduction, holds for electrolytic conductors, the curve in the latter case being not a straight line but having rather a boomerang shape. (See Curve II., Fig. I., taken from experimental work done by me.) It is seen that below a certain point, P, on the curve very little current passes through the above-mentioned electrochemical system, but that when a certain critical point, P, is reached the current starts to flow quite rapidly. This point P is about 1.67 volts for 5 per cent. H_2SO_4. Below 1.67 volts the current is slight. Above this point the current starts and is found to be roughly proportional to the voltage impressed less 1.67 volts.

The system acts very much like a safety-valve set to blow off, we will assume for sake of simplicity, at 167 pounds to the square inch. The safety-valve leaks so that a little steam will pass through it while the pressure is around 100 pounds. But this steam that passes through is small in

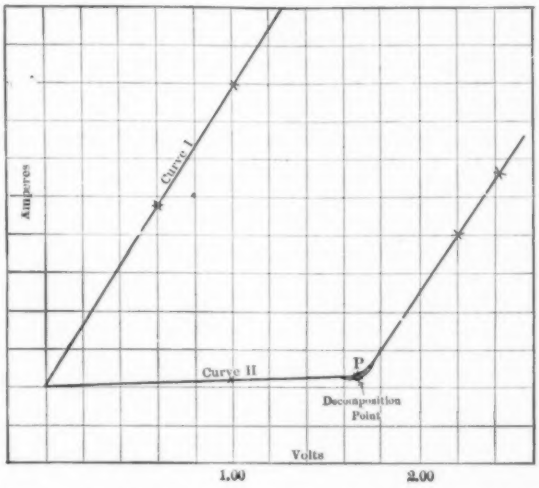


FIG. 1.—METALLIC AND ELECTROLYTIC CONDUCTION.

quantity compared with the steam that rushes out when the critical pressure of the safety-valve, 167 pounds, is exceeded by that of the boiler. The curve of the flow of steam as affected by pressure would be like that of the decomposition voltage curve II. of Fig. I.

Again, heat water under atmospheric pressure practically very little steam is evolved until the temperature of the water is 100° C. Then the dissociation of the water molecules into the simple gas molecules generates pressure large enough to drive off continuously the steam into space. The phenomenon is the same in all three cases; a certain critical pressure must be overcome, then the transfer of matter is proportional to some function of the effective pressure. By effective pressure is meant the impressed pressure less the critical counter pressure.

Now, we see that the electrochemical system possesses no wonderful characteristics that make its action different from that of any other system, but that it acts simply in accordance with general laws that govern the transfer of matter.

We must modify Ohm's law for electrolytic conduction.

$$\text{Amperes} = \frac{\text{volts impressed—critical voltage}}{\text{ohms}}$$

or

$$\text{Amperes} = \frac{\text{net volts}}{\text{ohms}}$$

This critical voltage, or voltage of "polarization," is the number of pounds at which the nature of the electrochemical system, cathode-electrolyte-anode, sets our electrochemical safety-valve. Vary these and we have a different value for the

critical voltage. With platinum electrodes, the voltage is 1.67 volts. With lead electrodes the voltage is 1.90 volts. Change the acid to normal hydrochloric acid and the voltage is 1.31 volts.

The term "critical-voltage," or "decomposition-voltage" (*Zersetzungsspannung*) is preferable to the term polarization, because polarization is a term used in electromagnetism, and in optics to entirely different phenomena.

The "critical-voltage," or "decomposition-voltage" is made of two voltages, or potentials, viz: The "electrode-potential," or "electrode-voltage" at the cathode and the electrode-potential at the anode. We must make the assumption that the electrolyte is of uniform composition and consequently exclude the disturbing factor of voltages due to differences of concentration in the electrolyte.

We can express this as follows: Critical voltage = anode voltage + cathode voltage or electrode voltage:

$$E = e_a + e_c$$

To measure these two voltages we must have some standard electrode that is called zero, as we assume the pressure of the atmosphere is equal to zero when we measure the pressure of the boiler.

Two arbitrary standards have been proposed:

First, that the KCl—n, Hg_2Cl_2, Hg system, called the "calomel-electrode," be placed at —0.560 volt.

Second, that the H_2SO_4 (normal as regards the hydrogen ions) H_2, Pt system be placed at 0.00 volt.

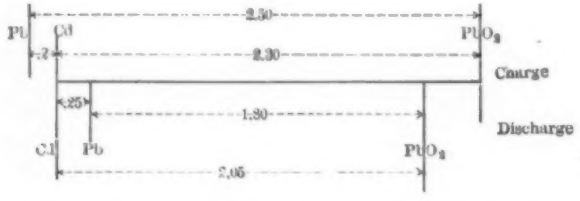
Both these have advantages for scientific investigation, but both are of little use for practical work. Zinc, cadmium, copper auxiliary test electrodes are easy to make and use, and are fairly steady. While not accurate to the millivolt, they are sufficiently accurate for working conditions. Their values can be referred to the above standards, either experimentally or by referring to the literature on the subject.

It is apparent that the critical voltage of any system is made up of the algebraic sum of the anode and cathode voltage. It is immaterial whether this system be made artificially as in the primary cell, or electrochemically as in the secondary cell.

In the secondary cell, the best type of which is the familiar lead accumulator, we have electrolytically reduced lead as anode on the discharge and electrolytically formed peroxide of lead as cathode on the discharge. The apparent ampere density is small and the internal resistance small. Consequently the CxR loss in all is small and the drop across the terminals is almost entirely due to the sum of the two electrode potentials. This voltage is a measure of the intensity of the anode to combine with anolyte and cathode to combine with catholyte.

To separate the two, we measure the electrode against a cadmium electrode or a zinc electrode.

These values, taken from Lyndon's new book, "Storage Battery Engineering," are read on discharge, and include the



loss due to the drop in internal resistance. The curves in Fig. 2 (taken from Dolezalek, *Die Theorie des Bleiaccumulators*) show that the peroxide plate is less reversible than the lead plate. This is due to the fact that lead is a better metallic conductor than lead peroxide. It is easy by means of the auxiliary electrode to see which plate is giving out first.

The sharp jump at the end of charge is due to the fact the system has been charged and we have a different stage of oxidation. This is sharper when the accumulator is charged at low current densities. The sharpness of the bend is a measure of the excellence of the accumulator. The sharper the curve the more reversible the cell.

In the case of the reversible copper-oxide, respectively copper plate, there are several of these jumps due to the fact that the active material of the plate is susceptible of several states of oxidation. Each oxide of copper has its own electrode voltage, and the jumps are due to the changes from one oxide to the next higher (see W. McA. Johnson, *Transactions of American Electrochemical Society*, Vol. 1., No. 1., p. 187). If we raise water by means of a pump to a series of barrels

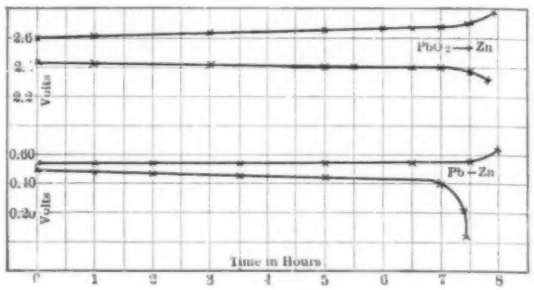


FIG. 2.—LEAD ACCUMULATOR.

placed at different levels, say 30 feet difference, the pressure pump must overcome to raise water is first fifteen pounds. When the first barrel is filled, the pressure rises immediately fifteen pounds, and so on through the series. The analogy is complete if the barrels are of large capacity and low height. Another analogy can be drawn to the dissociation of $CuSO_4 5H_2O$. Here we have the dissociation pressure of the hydrate which can be measured in pounds to square inch, or millimeters of mercury. It is a striking instance of the similarity of different phenomena. Fig. 3 shows the different electrode voltages of various oxides of copper against the KOH, H_2, Pt normal electrode.

An electrochemical system can have an electrode voltage equal to zero. In this case E = O, for $e_a = -e_c$. This is the case with a great number of soluble metallic anodes, and can be considered best by the familiar copper electrolysis with soluble copper anode, acidulated copper sulphate as electrolyte,

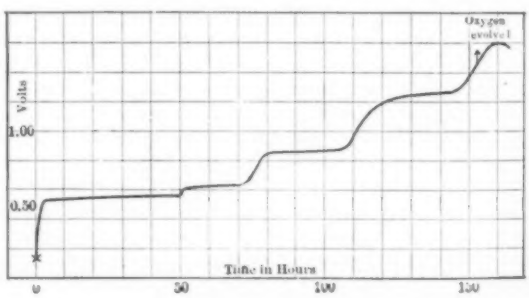


FIG. 3.—CURVE SHOWING THE DIFFERENT ELECTRODE VOLTAGES OF VARIOUS OXIDES OF COPPER.

and any metal as cathode, for the copper is immediately precipitated on the cathode, which becomes a copper cathode.

Here we have very little voltage on open circuit, for cast copper has almost exactly the same voltage as electrolytic copper. The anode voltage is equal and opposite to the cathode voltage, the small counter E. M. F. is due to concentration changes at the electrodes. Consequently a very small amount of energy is necessary to transfer a small amount of copper from anode to cathode. The state of affairs can well be described as an electrochemical "Atwood's machine," for

the flow of matter is in each case proportional to some function of the difference in pressure.

If the Atwood's machine were immersed in oil, or in some liquid that offered great friction to the weights, the analogy

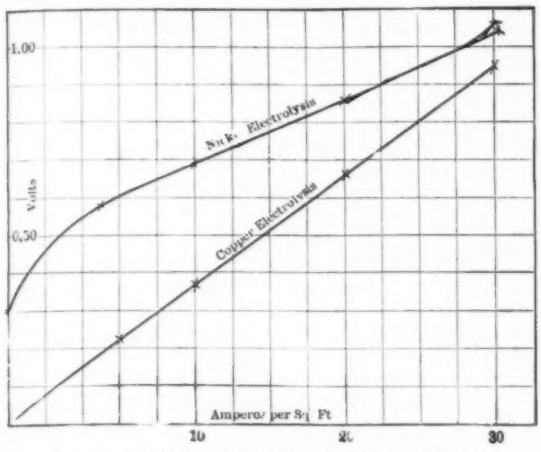


FIG. 4.—NICKEL AND COPPER ELECTROLYSIS.

would be complete, for the flow of matter would be directly proportional in each case to the difference in pressure.

In one case the difference of pressure would be measured in pounds, and in the second case would be measured in

Another instance of change in electrode voltage can be seen in the depolarizing action of liquids and gases. For example, in my article in the ELECTROCHEMICAL INDUSTRY, April, 1903, I mentioned that the use of SO_2 in an electrolyte of H_2SO_4, with PbO_2 as anode reduced materially the anode potential. This can be seen graphically in the curve of Fig. 5, taken from an old note-book of mine. The formation of SO_3 reduces the back electrolytic tension of the oxygen of lead peroxide so that the voltage is reduced by 0.50 volts. If the reduction figured on the equation $e_1 - e_2 = \frac{0.058}{n} \lg \frac{P_1}{P_2}$ it will be seen that the reduction of the electrolytic pressure would be measured in millions of atmospheres.

A number of other examples might be quoted, but these few are illustrative of others, and it is hoped will suggest to the readers others.

Subsequent articles in this series will treat the question of electrode voltage in the terms of the dissociation theory, and will discuss the various methods of measuring electrode voltage.

EIGHTH ANNUAL MEETING OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION.

The eighth annual convention of the American Foundrymen's Association was held on June 9, 10, 11 in Milwaukee, Wis., 210 members being present. The convention turned out to be a great success.

The presidential address of Mr. A. W. WALKER, of the

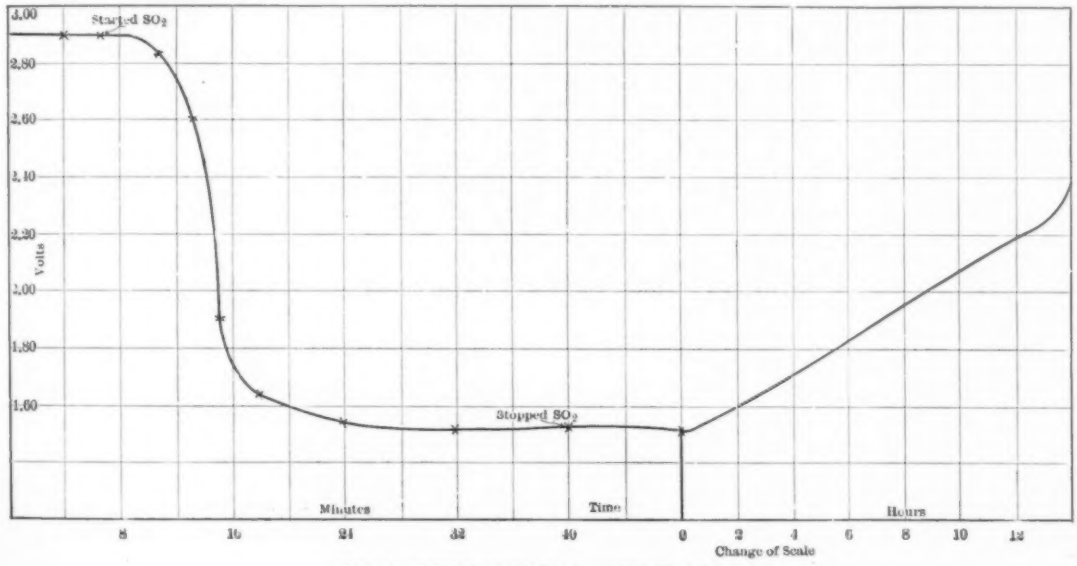


FIG. 5.—DEPOLARIZATION EFFECT OF SO_2.

volts. Fig. 4 shows that the "volts-amperes" curve is practically a straight line. Such a system is the most perfect reversible system that is known. The loss is due, not to polarization effects, but to the C.R loss due to ohmic resistance.

In nickel electrolytic work, the case is quite different. Here the anode of cast nickel requires electrolytic energy to break up the alloys of nickel existing in it, and it also requires more energy to deposit nickel hydride at the cathode. Fig. 4 shows the irreversibility of nickel electrolysis. The bending on the upper curve shows the polarization. In other words the electrode voltage increases with increase of current density. Of course such a perfect reversible combination as the copper electrolytic system will show polarization effects, but only at increased current density. Nickel electrolysis and copper electrolysis are markedly different in these respects.

Walker & Pratt Manufacturing Co., of Boston, dealt mainly with the *Labor Problem*. He compared the present situation in the business represented by the Association—a powerful labor organization on one side, and no less powerful associations for the defense on the other—with that of the nations of the world, with respect to their naval armament. As strong navies are a guarantee to continued peace, so large and constantly increasing funds available for instant use by these strong organizations, may insure industrial quiet. But great military and naval strength, while doubtless the most practicable peacemaker now, will in some time be obsolete for that purpose. As the increasing effectiveness of modern weapons makes war absurd, unreasonable, and, finally, impossible, so large reserve funds may in time cease to be the chief reliance in dealing with labor. The manufacturer who is wisely build-

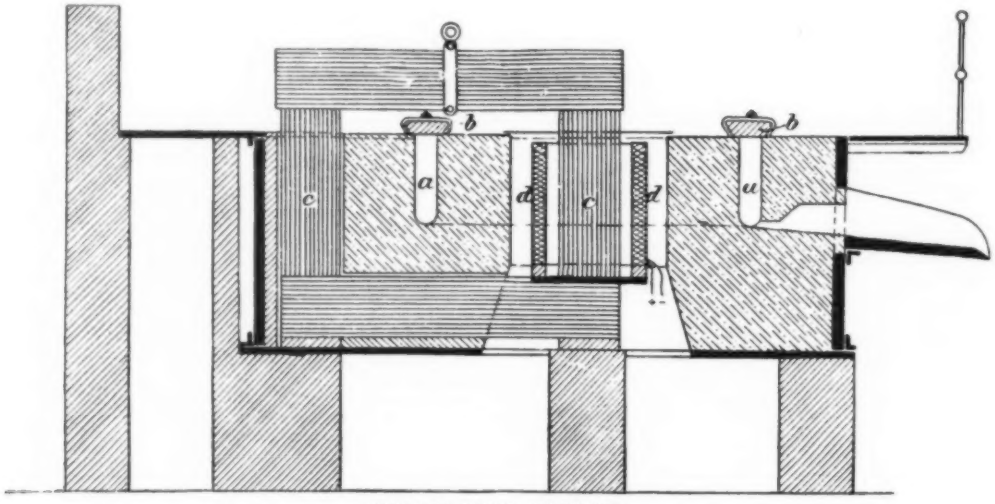
ing for the future, will study to work with his employees, rather than against them, to please them, to unite his managing ability with their muscle and skill. A first step will be to study the comfort and convenience of employees. Moreover, it will be found impossible to permanently withhold from the workmen a fair proportion of income from the manufacturing enterprise. The liberal-minded manufacturer will not object to an advance of wages in prosperous times. When dull times return the men must expect the inevitable reduction of wages; if they are entirely satisfied that they are based upon the true state of the business, they will accept such reductions with content.

Mr. Walker does not contend that the earnings of the men should be in direct proportion to the profits of the employer, but that earnings do and should bear some relations to profits. Many contests have arisen over this matter, some due to insufficient information, or an unreasonable concealment of real conditions by the employer. If the manufacturer would give as much time and thought to informing and educating his employees as he now spends in pleasing his customers, the effect would be helpful. Sometimes an employer may go so far in prosperous times as to distribute a portion of his profits among his men. But it is not entirely a question of money with the American mechanic. The rapid development of business has separated him from his former contact with his employer; his imperfect notion of profits and similar matters has made him discontented. The professional labor agitator is a logical product of the time; employers should make him unnecessary, and we shall hear no more of him. The manufacturers who will achieve the highest development and success during the next ten or twenty years, will be those who recognize the present conditions as temporary, and put themselves in line for harmonious and cordial relations with the men who are doing for them in factory or foundry the work which they themselves would do if the size of their enterprise would permit.

Dr. R. Moldenke, of New York, in his report as secretary, pointed out that only by educating the present and coming labor will be overcome the evils that are steadily growing and hampering the full development of the industry. To do this, one must begin at the bottom and furnish the apprentice the means to acquire the information that is to be the foundation of his life work. He recommended that short and elementary instruction papers be prepared under the direction of a special committee, and issued by the Association to the foundrymen at cost, for distribution among the employees. He also supported the suggestion made by Mr. Stanley G. Flagg, Jr., of Philadelphia, to do something in the way of original investigation for the purpose of overcoming difficulties in foundry practice. A committee was appointed, with Mr. Flagg as chairman, to take up such original investigation.

Among the papers presented at the meeting were the following: T. D. West, "A Cupola Slag Conveyor;" A. W. Walker, "Mechanical Device for Ascertaining the Average Silicon in an Iron Mixture;" J. C. Knoeppel, "The Continuous Operation of the Iron Foundry;" F. W. Stickle, "Foundry Responsibility;" R. P. Cunningham, "Foundry Control;" D. Spence, "Foundry Management;" J. A. Murphy, "Permanent Molds;" E. Richelieu, "Note on Continuous Molding;" E. Gilmour, "Molding Machines;" S. H. Stupakoff, "Molding Machines;" A. M. Loudon, "Trials of a Foundry Foreman;" J. G. Stuart, "Technical Education in the Foundry Office;" William Hanson, "Estimating Methods;" W. J. Keep, "Retort Oven Coke for Foundry Use;" R. Moldenke, "Malleable Cast Iron;" S. H. Stupakoff, "Employer and Employee;" W. H. Carrier, "Heating and Ventilating Foundries and Machine Shops on the Fan System;" S. S. Knight, "The Principal Factors of the Iron Industry in the Birmingham District;" W. E. Dickson, "Loss of Suphur in Borings of Pig Iron;" H. Souther, "The Metallurgical Engineer in the Foundry" (see Current Notes); W. W. Davies, "Blast Furnace Conditions Affecting the Chemical Composition of Foundry Iron."

Mr. Willis Brown, Walker Foundry Co., Erie, Pa., was elected president of the Association for the next year. A visit to the works of the Allis-Chalmers Co., at West Allis, a suburb of Milwaukee, on the afternoon of June 10, was greatly enjoyed by the members of the Association.



KJELLIN STEEL FURNACE.

ELECTRIC STEEL FURNACE AT GYSINGE.

The Kjellin electric steel furnace, in operation at Gysinge, Sweden, is interesting on account of the fact that it contains no electrodes, the heat produced in the hearth of the furnace being due to currents set up in it by induction. From an article of the inventor, F. A. Kjellin, in *Jernkotorets Annaler* (see also *Glueckauf*, 1903, No. 4, p. 77), we gather the following information.

The adjoining diagram shows the general arrangement of the Kjellin furnace. The annular space *u a*, the bottom and sides of which are formed by masonry work, is the hearth of the furnace; the cover *bb* of the furnace is removable. *C* is a rectangular magnetic circuit, formed of thin, soft iron plates. The coil *d d* is connected to the terminals of an alternating current generator.

The arrangement may be considered as an alternating current transformer, the coil *dd* being the primary winding, while the secondary is formed by the material to be fused. After some preliminary experiments the first steel was produced in March of 1900; but while the properties of the steel produced were quite satisfactory, the dimensions of the furnace were too small to allow an economical operation; the furnace held only 80 kg of material, and with the 78 kw dynamo at hand not more than 270 kg of cast steel were produced in twenty-four hours.

A new and larger furnace gave considerably better results, as with a 58-kw generator 600 to 700 kg of steel were produced in twenty-four hours; the furnace held 180 kg, and for the treatment of each charge of about 100 kg, three to four hours were required. Nevertheless the output per horsepower hour was not yet satisfactory, there being great losses due to radiation; the expenses of repair of the furnace per ton of steel produced were also higher than they should be in a large furnace.

When, at the end of 1901, the re-erection of the steel works at Gysinge was undertaken, it was decided to install a 300-hp turbine directly coupled with the alternator for the steel furnace. The new furnace holds 1800 kg, and when charged with cold raw material, it is able to produce at least 1500 tons per year. The voltage of the alternator is 3000. The works are intended for the production of tool steel of the best kind and the properties of the steel made are said to be excellent, which is thought to be due to the fact that the steel is entirely free from gases.

Some interesting tests of steel made in the electric furnace at Gysinge were published by Benedicks in the *Zeitschrift f. physik. Chemie*, v. 40, 5 (an abstract of this paper being given in *Elektrotechnische Zeitschrift*, 1902, Sept. 11). This steel was found to be very homogeneous and free from gases. The results obtained by the same author on the electric resistivity of steel as a function of the composition are also interesting. Chemically equivalent quantities of different materials dissolved in iron increase the electric resistivity by the same amount, according to the following law: One dissolved gram atom per 100 gram atoms of solution increases the resistivity by 5.9 microhms for a cubic centimeter; this is correct for additions of C, Si, Mn, P, Wo, and Al. Carbide in iron has no appreciable influence. The resistivity of absolutely pure iron at ordinary temperature is 76 microhms for a cubic centimeter.

NOTES ON A CLASSIFICATION OF ELECTROCHEMISTRY.

BY CLINTON PAUL TOWNSEND.

(*Continued from page 237.*)

AQUEOUS BATH, APPARATUS.

Electrolytic apparatus, and more especially apparatus designed for technical work, is usually constructed for a specific purpose; accordingly the apparatus is best included with the process in its appropriate class, it being in fact often difficult to determine whether the novelty is inherent in the method or the device. Certain classes of devices are, however, capable of diverse uses, and being unrelated to any specific method of operation, are conveniently assembled in a separate sub-class. Such, for instance, are the various holders or clamps employed for separating objects in plating baths, and such elaborate machines as those used for electroplating arc carbons; the screens and patterns employed for "shadowing" articles during plating to produce deposits of unequal thickness, or to guard against marginal growths; and cells for conducting electrolytic operations under special conditions of pressure, temperature, etc. This sub-class may also include cells designed for such peculiar use as the electroplating of ships' bottoms, and provided with means for holding them in operative position.

AQUEOUS BATH, CATHODES.

The cathode, like the anode, is often merely a means for establishing a connection between the electrolyte and the generator; often, however, it is designed to accomplish quite a distinct result. For instance, it is formed for the production by direct deposition of particular articles, such as tubes, wirebars, trolley wheels, or the air chambers of pumps; it may be prepared, as by treatment with oil, graphite, sulfur or sulfids, or by oxidation, to permit the ready stripping of a deposit, in which case metal films or "papers" may be produced, such cathodes usually taking the form of a revolving cylinder or moving belt, in order that the process may be made continuous; in some cases this preparation of a brilliant surface to which the deposit will not adhere is applied to specially designed cathodes, as, for instance, in the elaborate methods and devices for the direct production of parabolic reflectors; and in cases where a spongy deposit requires to be collected as in the recovery of tin from scrap, the form of the cathode may be adapted to this end. Again the novelty may lie merely in the form or character of the cathode, as in the copper-plating of the hulls of vessels, in which case the elaborate devices which adapt the bath to the work may be cross-referenced into this class. In general the class is intended to include reference to such electrodes as by their form, material or design are especially adapted to serve as cathode.

AQUEOUS BATH CATHODES, METALLIZING.

Such cathodes as are referred to in the preceding section are of metal or carbon. In many cases, however, as in electrotyping methods, it is necessary to deposit the metal upon a surface which is primarily non-conducting, and such surface must therefore receive a conductive coating with suitable electrical connections thereto. Graphite and metals in a state of minute subdivision are in general the conductors used, but a vast amount of careful work has been done with a view to hardening the form or matrix to render its surface sufficiently resistant, and to prevent the penetration of the electrolyte, and for the purpose of securing an even coherent and polished coating of the metallizing agent. When graphite or metal powders are used, these are generally brushed or blown over the surface of the matrix, and the devices therefor are classified under this heading. When a more nearly absolute conformity to the original surface is required, as in the reproduction of sound records and delicate surfaces generally, recourse is had to precipitation methods in which the metal is separated from its solutions by a chemical reducing agent, the methods often resembling closely the photographic development processes; or to methods depending upon the use of the static discharge in vacuo. The tenuity of the coatings produced by this latter method is extreme, and the deposits conform to the surfaces with an exactness which approaches the absolute. These vacuum deposits have been studied in other and independent relations, and, therefore, it is found advisable to establish for them a separate class with appropriate cross-references. In the case of vitrified surfaces, glass, tile and porcelain, adhesion is often secured by firing a mixture of salts with simultaneous reduction, the subsequent electro-deposits being frequently of such character as to bind the pieces into a design or mosaic.

AQUEOUS BATH CATHODES, METALLIZING, POROUS SUBSTANCES.

By reason of the number and variety of the published methods of metallizing non-conductors, it is found convenient to segregate the methods which are particularly applicable to porous materials, such as fabrics, a line in which some excellent work is now being done in this country. Heavy fabrics, coated with copper and darkened by suitable after treatment, may be used as wall coverings, while lighter fabrics or laces, stiffened by a suitable deposit, may be made into lampshades, etc.

AQUEOUS BATH, INORGANIC COMPOUNDS.

In addition to the somewhat extended literature relating

to the deposition of the metal and the physical characteristics of the deposit, this class is conveniently extended to include the work of Hittorf and others upon the passive state. This particular phase of the subject is, of course, bound up with the study of the passive state assumed by iron, nickel, cobalt, etc.

Aqueous Bath, Colloidal Metals.

The electrical methods whereby the metals have been obtained in the colloidal state are distinguished from others under the general class of aqueous bath, in that they do not depend upon the electrolytic effect of the current, but on the action of a luminous arc under water or dilute aqueous solution. It is convenient, however, to extend this class to include reference to the strictly chemical methods for the production of colloidal solutions, and the action of the same under the influence of electrolytes and of the electric current. This subject is, of course, cross-referenced to or from the appropriate classes designed by the names of metals.

Aqueous Baths, Inorganic Compounds.

The subdivisions of compounds being mutually exclusive and together covering the entire field, there is no residual or generic class. Of the inorganic compounds, those in the production of which the greatest activity has been displayed, to wit., the products of decomposition of the haloid salts, and the pigments, have been assigned to separate classes; and the sulphates are also separately classified. The remaining references, therefore, constitute a class which is by no means unwieldy, and which includes such anodic reactions as the production of manganates and permanganates, chromates and bichromates, percarbonates and pertungstates, and the formation of alums; such cathodic reactions as involve the reduction of nitrates, carbonates, etc.; and such general methods as those of Lorenz for the production of insoluble hydroxids and sulfids. These latter should be cross-referenced into the class of pigments, and, in fact, it is found convenient to cross-reference into that class all methods which result in the production of compounds which are insoluble in the electrolyte, even though their employment as pigments is not indicated, the analogy of the methods constituting a sufficient reason. The described methods which yield cyanogen, cyanogen halides, and other solvents for the precious metals should be cross-referenced from the present class into those which relate to the treatment of ores.

Aqueous Bath, Organic Compounds, Oxidation Methods. Aqueous Bath, Organic Compounds, Reduction Methods.

In general, electrolytic methods which involve the transformation of organic compounds are distinctly anodic or cathodic, the electrolyte often having no other apparent function than to serve as a solvent or suspension medium for the compound undergoing reaction, and to furnish oxygen or hydrogen for its conversion; the material of the electrodes and the current density are the vital considerations. Certain reactions which are usually effected without a diaphragm, as the production of the halogen substitution compounds chloroform, bromoform and iodoform, are conveniently included under the broad class of "organic compounds," and thence cross-referenced into the class of haloids. For a closer subdivision of the abundant and rapidly accumulating references to the literature of the applications of electrolysis to organic chemistry the usual classification of the science may be followed.

Aqueous Bath, Copper.

This sub-class excludes the great commercial application of electrolysis to the refining of the metal, but includes the plating methods. Copper is usually the metal involved when special forms, as tubes, wire-bars, etc., are to be produced by direct deposition, in the formation of stained glass windows or mosaics, in the electrolytic setting of bort or abrasives, and in similar applications classified under cathodes, but the use of the metal is so general that no useful purpose is served by cross-referencing these applications into the plating class. On the other hand this extended use has led to a correspondingly full study of the physical character of the deposits as related to the composition of the bath and the current conditions, the subject matter of the present class.

Aqueous Bath, Gold.

This sub-class is restricted to the plating of the metal, the refining methods and the separation of the metal from its ores being referred to other titles. Even the precipitation of gold from its natural solutions, as in certain suggested methods for its separation from sea-water, is best classified under "Ores," these methods being, in fact, merely the usual ones employed for the treatment of solutions obtained by the action of appropriate solvents upon the ores with such modifications as are supposed to adapt them to the extreme dilution of the natural solutions.

Aqueous Baths, Haloids.

This sub-class deals with the electrolysis of sodium chlorid and other haloid solutions, whatever be the products sought or the conditions of the work. It thus represents one of the most complex, interesting, and commercially important branches of electrochemistry. The sub-class might be subdivided along the structural lines, for those cells in which a septum, in the form of a porous diaphragm, a body of mercury, or a partial partition, is interposed between the chlorin and caustic compartments, are in general intended for the collection of caustic (or carbonated) alkali and chlorin, whereas the undivided cells are used for producing hypochlorites, chlorates, or perchlorates. Such a division of the class would, however, be somewhat misleading, for cells of each of the kinds mentioned have been described as suitable for each distinct purpose. It is advisable rather to segregate from the main title of haloids certain subordinate classes below referred to.

The residual class embraces (1) the theory of the decomposition, which, in this subject matter, bears an extremely intimate relation to the construction of the cell and the manner of operating it; (2) all cells and cathodes designed for the collection of chlorin or other halogen and caustic alkali or alkaline earth hydroxids, whether of the "diaphragm" or "gravity" type, excluding only those employing a cathode of mercury; (3) cells involving the use of soluble or non-polarizable anodes, whereby the chlorin is collected as a soluble or insoluble salt.

It is clear that a much closer subdivision of this general matter is feasible; thus it is common to distinguish between caustic cells of the diaphragm and gravity types. Experience has shown, however, that this is not advisable, for the reason that the whole trend of recent construction is to combine these types, utilizing the diaphragm, but separating the caustic therefrom by gravity. Furthermore, the very complexity of the reaction of decomposition, whereby every cell yields at least traces of every product, is an argument for unifying the subject matter.

Aqueous Bath Haloids, Bleaching and Disinfecting Liquors.

These products are in general hypochlorites, hypochlorous acid, or solutions of chlorin, the last two being anode products and the first the result of the reaction between anode and cathode products. Accordingly the cells may or may not be compartmental, the latter type predominating. The conditions favor the series connection of the electrodes, and recent progress has been almost confined to devising means for increasing the efficiency of the cells by guarding against the leakage of the current through the electrolyte between the oppositely polarized faces of the intermediate electrodes. Aside from the materials used the cell constructions often closely resemble those used for the refining of metals.

Aqueous Bath Haloids, Chlorates.

The cell constructions closely resemble those of the preceding sub-class, the series arrangement being, however, less commonly applied. Recent interest has centered in the theory

of the reaction, and the observed effect of the addition to the solution of chromates and bichromates. Perchlorates are conveniently included in this sub-class.

AQUEOUS BATH HALOIDS, MERCURY CATHODE.

This sub-class is nearly coextensive with the electrolytic production of chlorin and caustic alkali by the aid of a cathode of mercury, the other grade industrial use of the mercury cathode being referred to "Aqueous Bath, Ores." Aside from the production of caustic, it is well, however, to include such work as that of Guntz and Féréé on amalgams, and the methods of Kellner and others for the reduction of nitrates, organic compounds, etc., the last being, of course, cross-referenced to its proper title.

AQUEOUS BATH HALOIDS, TREATING CATHODE LYES.

It is intended to include here a range of interesting methods, the object of which is generally to overcome the backward diffusion on caustic by converting it into a less soluble compound, or by diverting the alkali metal to other uses than the decomposition of water; usually the compound formed is the carbonate or bicarbonate of the alkali metal. By extensions of these processes it has been proposed to obtain the most varied products, such as white lead, phosphates, soaps, rectified spirits, and even metals. The sub-class properly contains all methods wherein alkali metal is used for other purposes than the decomposition of water or the production of an amalgam.

AQUEOUS BATH, IRON.

An extensive and important literature deals with the deposition of the metal for industrial uses, as for the facing of electrotypes, and for the purpose of studying its magnetic properties, and its relations to carbon; its property of assuming the passive state under certain conditions has also been closely studied.

AQUEOUS BATH, LEAD.

The cathodic deposition of the metal and its anodic separation as peroxid.

NICKEL AND COBALT.

Both anode and cathode deposits are included. The records of the Patent Office show that during the interval between 1868 and 1880 nickel-plating was perhaps the most active of the electrochemical subjects of invention, but more recently attention has been given almost exclusively to the separation of the metal from copper and the production of heavy deposits of high purity.

AQUEOUS BATH, ORES.

The electrical treatment of ores generally involves the two distinct operations of solution and precipitation, the former being often, and the latter nearly always electrolytic. Electrolytic solution may involve the use of an ore or matte anode, or simply the preparation by electrolysis of such solvents as the oxyhaloid salts, the chlorid of cyanogen, etc. The precipitation may be a simple plating method; it may involve the use of mercury to receive the deposit, or, and most frequently, the precipitation may be accomplished by the employment of a properly chosen couple, no external source of current being used. So numerous and varied are the applications of this latter principle that it has proven advisable to establish the sub-class "Reduction by Couple" below referred to.

AQUEOUS BATH ORES, GOLD AND SILVER, CYANIDES.

The function of the current in the cyanid methods may be two-fold; it may directly or indirectly furnish the oxygen required by Elsner's equation, or it may accomplish the precipitation. In most cases the two are combined.

AQUEOUS BATH ORES, GOLD AND SILVER, HALOGENS.

The chlorination methods often involve the use of electrolytic chlorin, the production of which relates to the sub-class of "Haloids." So far as concerns the present title, the current may yield chlorin in the bath containing the ore, or produce hypochlorites, hypobromites and similar solvents, or may effect the precipitation of the metals dissolved, the three operations being often combined.

AQUEOUS BATH ORES, ZINC.

The methods for the treatment of zinc ores are sufficiently distinctive to permit a separate classification.

ORGANIC NON-ELECTROLYTES IN PLATING.

The action of non-electrolytes under the influence of the current has its industrial applications, classified under the succeeding title, and under "Tanning." The present sub-class deals with the addition of non-electrolytes, in most cases colloids, to metal plating baths. The purposes sought are various, as the prevention of anode deposits of peroxid; the modification of the character of the cathode deposit; the modification of the physical character of the electrolyte, as in cases where it is desired that the evolved gas should be permitted to act upon an electrode; the prevention of oxidation of components of the electrolyte, etc.

OSMOSE.

The osmotic effect of the current in mechanically transporting water and non-electrolytes in solution has been applied to the extraction of moisture from wood and peat, and a variety of similar materials; to the extraction of sugar from comminuted cane or beets, and to the impregnation of wood by preservatives. In general, a permeable cathode is employed, the material itself often serving as the diaphragm.

PICKLING.

In addition to strictly electrolytic pickling methods, in which a metal sheet to be cleaned is supported as an electrode in an appropriate bath, it is convenient to include under this title such chemical processes as are particularly adapted to the preparation of the plates for the deposition of metal.

(*To be concluded.*)

PROF. F. HABER ON ELECTROCHEMISTRY IN THE UNITED STATES.—II.

(*Concluded from page 351.*)

In connection with the description of the Acker Process which Prof. Haber highly praises as noticed in our former article (ELECTROCHEMICAL INDUSTRY, 1903, June, p. 351), he gives a review of the various industrial processes used in this country for the electrolysis of sodium chloride. The Acker process is the only process in which fused salt is electrolyzed. A mercury cathode is used by the Castner Electrolytic Alkali Co. in Niagara Falls, according to the patents of Castner and Kellner (ELECTROCHEMICAL INDUSTRY, 1902, Sept., p. 12). These patents appear to cover the field so broadly that there is only one competitive undertaking in the same line; namely, by the Pennsylvania Salt Co., in Wyandotte, Mich., with the cell of G. and G. W. Bell, in which the mercury is said to be moved by an arrangement different from that in the Castner-Kellner process; the exit for the chlorine is alternately opened and closed, so that the chlorine alternately collects in the cell and escapes; while it collects in the cell, it pushes the mercury into a side chamber used for decomposi-

tion; when the chlorine escapes from the cell, the mercury, which has given off the sodium in the meanwhile, returns into the cell. The Rhodin process (Electrochemical Industry, 1902, Nov., p. 86) is briefly mentioned.

Diaphragm processes have come into extended use in this country. The diaphragm process of H. D. Dow has been in use for many years in the plant of the Dow Chemical Co., of Midland, Mich., The American Electrolytic Co. is completing a plant at Rock Glenn, near Buffalo, in which the Moore cell will be used, which is similar to that of Hargreaves. A greater number of paper and pulp mills, notably in the New England States, have installed in recent years their own electrolytic plants for making the bleaching liquid required in their mills; all of them use diaphragm processes. Dr. Haber compares their method of working with the process often used abroad of making hypochlorite in a cell without diaphragm and shows that this latter method would be less profitable under the conditions existing in this country; one of the main points is that very dilute bleaching liquid is unsuitable for pulp and paper mills, and that the production of strong hypochlorite solutions requires a comparatively very great consumption of power in cells without diaphragm; moreover the first cost of ordinary diaphragm cells is considerably less than that of the commercial hypochlorite apparatus. Dr. Haber thinks, however, that the hypochlorite apparatus should have a future in textile mills, for which purpose they have not yet been introduced in the United States; in this case more dilute solutions are required and the great simplicity of the operation of hypochlorite apparatus should be of importance.

Dr. Haber points out that the operation of diaphragm processes is much simpler than is generally supposed. For anodes Acheson graphite is mostly used, and in some cases platinum iridium. The diaphragm of asbestos paper or asbestos cloth is mostly supported by the iron screen cathode on which it is fixed; sometimes the asbestos paper is stiffened by covering it with a little cement by means of a brush. The electrolysis takes place in a hot solution (up to 80 degs. C.), the fresh electrolyte being continually supplied to the anodic room of the cell, so that the flow of the electrolyte is opposed to the passage of OH ions into the anodic department. The current efficiency depends not only on the details of the apparatus, but to a higher degree upon the degree to which the electrolysis is driven; the higher the percentage of sodium chloride, and the less the percentage of sodium hydroxide in the cathodic liquid, the better is the current efficiency. The proportion of hydroxide to sodium chloride in the liquid flowing out of the cathode department is mostly 2 to 3, sometimes 1 to 1, or even more; the current efficiency is under unfavorable conditions between 70 and 80 per cent, and under favorable conditions between 80 and 85, and may reach 90 per cent. With platinum iridium the e. m. f. per cell is 4.75 to 5 volts, with graphite electrodes 4.5 to 4.8 volts; the excellent durability of the Acheson graphite electrodes is pointed out.

The electrolytic production of chlorates is briefly referred to and a description is given of Darling's sodium process, which was in use on an experimental scale in the works of Harrison Bros.& Co.,in Philadelphia. "As an experiment, Darling's undertaking was highly interesting, but the proof that the process is of commerical value, has not been brought during the time while it was in operation." It was Darling's intention to use the sodium for making cyanide; there were found to be difficulties in this direction. As sodium is of importance as starting point for the production of various valuable chemicals, Dr. Haber thinks that it is probable that Darling's experiment may be revived or that new suggestions may be made.

The two big plants founded by E. G. Acheson—the carborundum and graphite works at Niagara—are then taken up and characterized as "nearly the only important applications of electric resistance furnaces in the United States." A brief description of these two plants is given (Electrochemical Industry, 1902, Oct., pp. 50 and 52). Descriptions of the plants of the United Barium Co. (Electrochemical Industry, 1902, Sept., p. 16) and of the Electric Lead Reduction Co. (Electrochemical Industry, 1902, Sept., p. 18), and a longer discussion of the process of the Atmospheric Products Co. (Electrochemical Industry, 1902, Sept., p. 20), follow. Dr. Haber says: "In spite of the importance of this undertaking, I cannot deny that its status of development has disappointed me somewhat after the descriptions which I had read in the papers. I expected to find an industrial operation, and I found an experimental apparatus; true, it is of very great interest, but as far as I can see it is not possible to judge with safety what the commercial result will be." The fact that the Atmospheric Products Co. is to undertake the operation of the process on a large scale, allows to conclude that under the present conditions of the chemical market the commercial success of the process is considered to be assured. If experience shows that the wear and tear of the platinum-iridium electrodes is indeed negligible as it was found to be the case up to the present, Dr. Haber thinks that the commercial success depends only on the cost of the power and the cost of changing the dilute nitrogen oxide vapors into strong nitric acid. The cost of production of a mixture of calcium nitrite and calcium nitrate would be low, but such a mixture is not suitable for fertilizing purposes, because nitrites are poisonous to vegetables. The production of moderately concentrated nitric acid (up to 55 per cent HNO_3) from the dilute nitrogen oxide vapors and water, appears to be feasible, but he doubts whether in view of the large plant required, the cost of this operation is low enough if it is only an intermediate operation in order to make finally nitrates for fertilizing; he also doubts whether the percentage of nitrous acid can be made sufficiently small in this operation. On the other hand, an acid of 55 per cent HNO_3 is still without value for the industry of explosive materials, and the question arises whether the cost of changing it into highly concentrated acid would not consume the profit of the electrochemical process. "A complete new industry has not yet been founded. Nevertheless it cannot be denied that here a highly important step has been made, and great credit is due to the Atmospheric Products Co. for its activity."

Dr. Haber then discusses at length the copper refining industries of the United States; he gives data on the plants of the American Smelting Works in Maurer, N. J., the Baltimore Copper Rolling and Refining Co., and the Anaconda Electrolytic Copper Refinery, and compares at some length the relative advantages of the series and multiple systems of cells. In the latter all the anodes are metallically connected and the same is the case with the cathodes, while in the series system there are numerous intermediate copper plates between the terminal anode and the terminal cathode of a cell. The question which system is the better one, has not yet been decided. The most splendid new plant of recent years, that of the American Smelting Works in Maurer, uses the multiple system. On the other hand the Baltimore Copper Works which installed years ago a combined multiple and series system, have enlarged the series system (Hayden system) more and more while the multiple system is restricted to a small portion of the plant.

The adjoining Fig. 1 gives a view of a series cell, or rather of a six independent series cells, which are separated from one another by slate plates. In the first cell on the left hand all the intermediate bipolar electrodes are plotted, in the others they must be assumed to be present in exactly the same number. The motion of the electrolyte is indicated by arrows. The small rectangular plates, shown at the points where the electrolyte enters into the cells, represent pieces of glass against which the fresh electrolyte flows when entering the cell, so that proper circulation and distribution of the solution is accomplished.

The advantages of the series system over the multiple system are said to be the following: An enormous saving of floor space, less evaporation of electrolyte, less electrolyte, and less

power consumption. The disadvantages of the series system are: first, that it requires relatively very pure anode copper, while the copper anodes in the multiple systems may contain more silver and impurities before difficulties in the operation arise. The second disadvantage of the series system is that it requires more attendance, its operation being more complicated. Dr. Haber refers to a fact which is highly interesting from a theoretical point of view, that is the very good influence of a very small addition of a chloride (hydrochloric acid or sodium chloride) to the electrolyte upon the copper deposit; this addition prevents arsenic and antimony from being deposited together with the copper. Dr. Haber gives finally some data on the cost. He compares the actual costs at Anaconda with the costs estimated by Siemens & Halske for similar conditions as exist at Anaconda. With average wages for workingmen at Anaconda about three times greater than those assumed by Siemens & Halske, the actual cost of operation at Anaconda is three times less than in the calculation of Siemens & Halske. "This is the best proof of the high mechanical development of the refinery plants in the United States, which are admired by anybody who visits them. This also explains why the small refineries with an output of a few tons of copper per day cannot compete with the larger plants, and why the whole refining industry of the country is concentrated in a few large works, which, with an output of 100 tons per day, or more, are alone able to install such admirable mechanical apparatus."

Dr. Haber then discusses the problem of lead refining. Keith has been a pioneer in this field, and a new process of Betts is now worked at Trail, B. C. (ELECTROCHEMICAL INDUSTRY, 1902, Nov., p. 105). Dr. Haber sums up his description of the Betts process as follows: The most suitable method of treating the slimes has not yet been definitely determined. How far the cost of operation can be diminished when the process is worked at a large scale, is also uncertain. It seems doubtful whether for a raw material of lead, which is poor in bismuth or free of bismuth, the process can compete with the ordinary metallurgical refining process in plants with a daily output of several hundreds of tons, although the inventor calls attention to the fact that in his process there is no loss of silver, while such a loss is unavoidable in the metallurgical process. Whether the operation will be free of difficulties with a material of lead containing a great many impurities must still be considered as an open question. But the process, as it is developed at the present day, is without any doubt of considerable value for plants with a smaller output, and should be taken into special consideration in the case of lead containing bismuth.

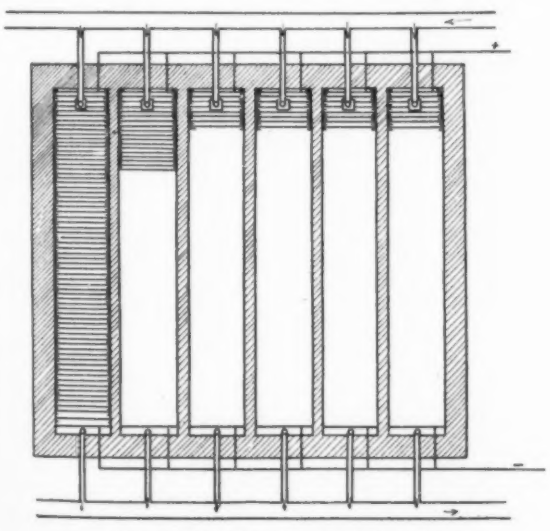


FIG. 1.—DIAGRAM OF SERIES CELL.

The electrochemical treatment of copper-nickel matter is then taken up. On a commercial scale the problem has been solved in this country only once, by David H. Browne. The experiments of Hoepfner, Frasch and Ulke have not achieved commercial success, while Browne has produced for years in Cleveland daily 454 kg pure nickel and a corresponding amount of copper; when the Cleveland plant was closed in 1902 by the Nickel Trust, this was done in recognition of the fact that as an experimental installation it has proven in all points the commercial feasibility of the process, and with the intention to erect at a more suitable place a larger plant in which either the same process is to be used or a modification of it, which will be mentioned below, this modification being adapted to the change of the commercial situation caused by the formation of the trust. The industrial problem is the treatment of the nickel-copper ores of Sudbury in Canada. The ores generally contain 2 per cent of Ni and the same amount of Cu. In Canada the ore is roasted and melted with addition of limestone and coke. The resulting matte generally contains 20 to 25 per cent of copper, 18 to 23 per cent of nickel, 25 to 35 per cent of iron and 26 to 33 per cent of sulphur. This matte is further treated in converters and the resulting product which contains 35 to 40 per cent of Cu, 35 to 40 per cent of Ni and ½ to 1 per cent of iron, the balance being sulphur and a trace of silicon, is now being treated for the separation of the nickel from the copper.

This treatment has mostly been done in the United States by the Orford process, which is not an electrochemical process. The Canadian Copper Company years ago decided to develop a competitive electrochemical method, and this problem was successfully solved by D. H. Browne. Since the formation of the Nickel Trust the situation has been changed, as it now controls both the Orford process and the Browne process, and it seems that under the present condition the cost of the former is somewhat lower. But besides the simple separation of nickel from copper, there is another problem, that of the production of very pure nickel. The nickel made by the Orford process is sufficiently pure for use in steel manufacture and for nickel anodes for electroplating, while for certain other purposes a further refining is desirable. The electrolytic process of Browne gives at once a very pure nickel. The following tests of nickel are mentioned. Two tests of Orford nickel gave the following composition:

Ni	Cu	Fe	C	S	Si
98.91	0.13	0.40	0.23	....	0.05
98.34	0.41	0.93	....	0.078	....

Cobalt is here included in the nickel. Some analysis of nickel, made by the Mond process, gave the following results, the first line referring to average samples, the second to very pure samples:

Ni	Cu	S	Fe	Si	C
98.32	0.064	0.058	0.513	0.034	0.914
99.34	0.014	0.007	0.225	....	0.335

The electrolytic nickel made by the Browne process has the following composition (being the average of the products of three months):

Ni	Fe	Cu
99.85	0.085	0.014

The metal is free of arsenic, sulphur and silicum. This nickel is said to be even purer than the nickel anodes formerly made by the Balbach Co.

Browne found that in a hot nickel chloride solution, free of sulphates, the Acheson graphite anodes prove so excellent that their corners and edges remain sharp after two or three years; only if the solution contains sulphates, they are destroyed like other carbon anodes. The Balbach Co. gave up the manufacture of nickel anodes some years ago, because 50 per cent. of the anode weight remained as scrap and had to be remelted; this increased the cost of melting and manual labor to such a

degree that the process became commercially unsuccessful. Dr. Haber then gives a detailed description of the Browne process. As the process has not been described before to this extent, as far as we know, we give this part of Dr. Haber's address nearly in full. The description appears to be complete, with three exceptions: the concentration, the exact temperature and the current density are not given, as the inventor wants to keep these points secret.

The Browne process may best be explained with reference to the adjoining Fig. 2, in which high concentrations or large quantities are represented by heavy face type, dilute solutions and small quantities by light face type; final products are put in parentheses [ ], raw materials in parentheses ( ). The matte in crushed form (the diameter of the grains being 1 mm) is first brought into the calcination furnace, and by means of roasting it is freed from sulphur. In the adjoining melting furnace it is then reduced by means of charcoal, and a coherent, although not dense form; it is sufficiently adherent, but it is more crystalline than the copper of copper refineries. Between 2 and 2.25 grams are produced per ampere hour, while the theoretical value is 2.36 grams. A very small amount of $CuCl_2$ is sufficient to account for this difference with the theoretical value.

The proportion of nickel and copper in the fresh electrolyte applied to these cells is the same as in the anodes, as the electrolyte is made, as will be described later, from the nickel-copper shot, which in its chemical composition is identical with the anodes. The electrolyte is a mixture of $NiCl_2$, Cu_2Cl_2, NaCl and $FeCl_2$. When the electrolyte flows off from the copper cells, the proportion of nickel to copper in it is 80 to 15. The cathodes are removed from the cells after three or four weeks. The copper thus produced is not dense and of a very crystalline structure, but a single melting process is sufficient to change it into commercial metal. If any silver is in the anode

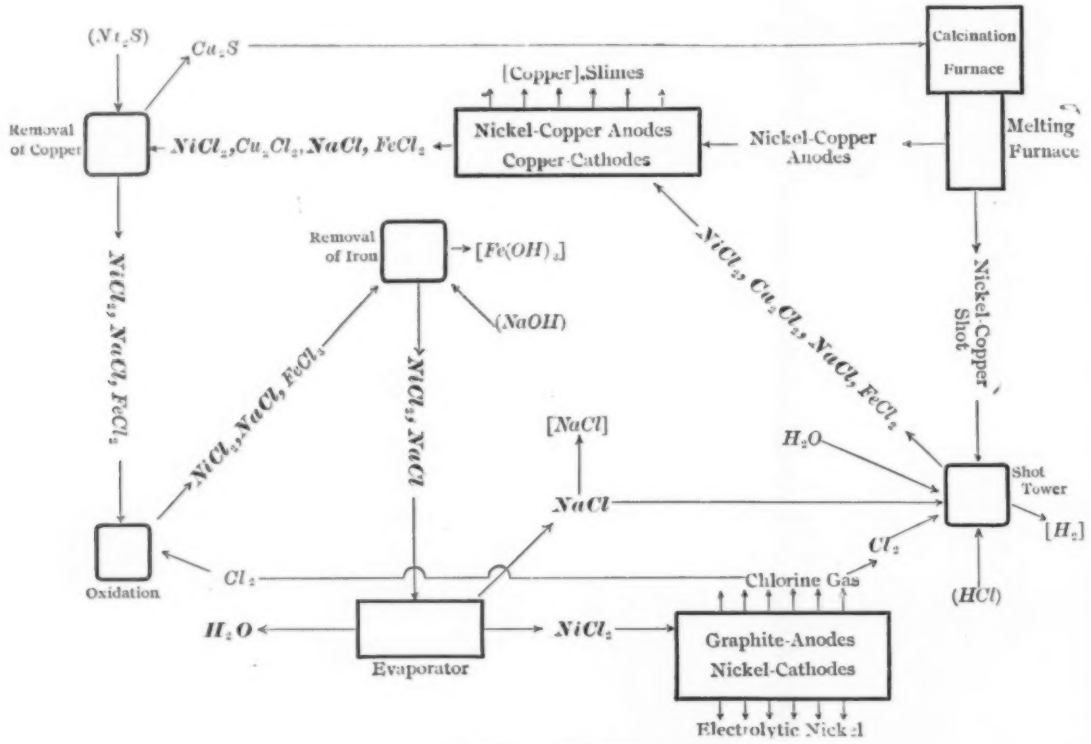


FIG. 2.—DIAGRAM OF BROWNE PROCESS.

one-half of the fused copper-nickel is poured into anode forms, the other half is poured into water, thus giving copper-nickel shot of a weight equal to that of the anodes. The anodes are placed in the nickel-copper bath; the copper-nickel in shot form is brought into the "shot tower." The composition is about Cu 54 per cent., Ni 43 per cent., the balance being iron and sulphur, the amount of iron present being generally below one per cent. In the shot tower the electrolyte for the copper depositing baths is made and flows continually over into these cells (or rather into a reservoir from which the cells receive their electrolyte). The ordinary multiple system is used. The anodes have a surface of 75 x 60 cm, and are 2.5 cm thick. Concrete tanks are used (see the description by D. H. Browne in Electrochemical Industry, 1903, April, p. 273); their dimensions are 256 cm length, 85 cm breadth, and 67.5 cm depth. Each tank has a capacity of 1,534 liters of the electrolyte. Circulation takes place by overflow from cell to cell; the cathodes are thin, electrolytically made sheets of copper. For 24 baths connected in series, the voltage is 6 to 10 volts, the current 500 amperes. At the cathode the copper is deposited in it passes completely over to the cathode, but the nickel copper matter is very poor in silver. The anode scrap is returned into the furnace. The anode slimes may be worked up to get the platinum metals, but this has not been done up to the present, as under the existing conditions such a treatment would not pay, and it was simpler to return the slimes to the furnace. The Sudbury ores contain in general a small amount of platinum metals; occasionally, however, rich samples are found, containing Pt As_2; very rich sands are also occasionally found, for instance in the Vermillion mine a sand containing 300 grams of platinum, 270 grams of palladium and 230 grams of silver per metric ton was found; it seems, however, that the rich ores or sands found are of small quantities, and that the large quantities of ores or sands found are not rich. To give an average figure for the percentage of platinum metals, the following composition is given by Ulke as the average composition of Sudbury matte used by the Canadian Copper Co. in the beginning of 1902: 13.2 per cent. Cu, 17.8 per cent. Ni, 0.45 per cent. Co, 42 per cent. Fe, 21.4 per cent. S, and 65 grams Ag, 12 gr Pt and 12 gr Pd per 1000 kg.

To sum up the result of the first step of the Browne process, as described above, it is the electrolytic separation of nearly all the copper from the nickel; the remaining nickel, however, still contains 1 part of copper to 80 parts of nickel; these remaining 1.25 per cent. of copper are chemically separated from the nickel by treating the electrolyte which flows off from the copper cells with sodium sulphide and by filtering the cuprous sulphide off. The solution which is now a mixture of $NiCl_2$ NaCl, and a small amount of Fe Cl_2 is then treated with some chlorine gas (which comes from the nickel cells as will be described below) in order to oxidize the ferrous chloride to ferric chloride. By means of sodium hydroxide the iron is then removed from the solution; after removal of the ferric hydroxide, the solution is a mixture of Ni Cl_2 and Na Cl and is then brought into the evaporator. This evaporator was described in ELECTROCHEMICAL INDUSTRY, 1902, Nov., p. 62; it is shown in the adjoining Fig. 3, which shows the brick furnace which contains the oil burner at the right hand at D; a current of hot air is produced which enters the evaporator by a sleeve and leaves it at the left hand to the chimney. The solution is continually supplied to the evaporator through the short tube indicated at the left hand and flows off into the basin, F. By passing through the apparatus the solution is brought to such a concentration that the total sodium chloride separates out and is carried in suspension over B to F, where it settles down. The solution now contains only $NiCl_2$, and while still hot, it is passed to the nickel depositing cells; nickel is deposited on the cathodes and chlorine developed at the anodes. The solution which thus becomes more dilute is returned to the evaporator.

The nickel cells are made of concrete and the multiple system is used, as in the copper cells. They differ from the latter in the size and in the use of porous diaphragms. As the electrolyte has become more concentrated, the size of the cells

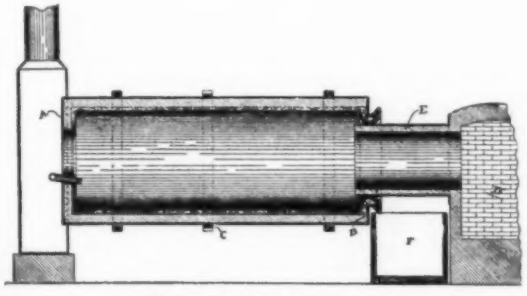


FIG. 3.—EVAPORATOR.

is 2.37 meters in length, 71.5 cm in breadth, and 40 cm in depth. The cathodes consist of strips of nickel of 38 cm length, and 14.7 cm breadth, several such strips being suspended side by side from a conducting rod across the cell. Opposite to each series of nickel cathodes there is provided a series of Acheson graphite anodes, each being surrounded by a porous clay cylinder, without bottom, the cross section being oval; the short axis of the ellipse (this axis is perpendicular to the surface of the electrode) is 8.75 cm long, the long axis 16.25 cm. These clay cylinders reach nearly to the bottom of the cells, although some space is left between their lower ends and the bottom, in order to make a free circulation of the electrolyte possible. These porous diaphragms prevent successfully any chlorine from passing to the cathodes and diminishing the current efficiency. The efficiency is therefore very good; during a period in which 10,000 kg of nickel were produced it was in the average 1.029 gr Ni per ampere hour, i. e., 93.5 per cent. of the theoretical current efficiency. The upper ends of these cylindrical tubes are connected to a cross tube of pottery ware with an asphalt coating through which the chlorine is led off.

Nearly the total chlorine is led to the tower containing the nickel-copper shot; only a small portion is used for the change of $FeCl_2$ to Fe Cl_3. The consumption of power in the nickel depositing cells is much greater than in the copper depositing cells. The voltage at the terminals per nickel cell is 3.5 to 3,6 volts; there is also some loss of voltage in the conductors and contacts so that about 5.3 horse-power hours are required per kilogram of nickel deposited in the cells. This figure is deduced from the following dates representing a test of the operation in 1902. There were consumed during the test 52,524 horse-power hours; duration of experiment 679 hours; average current 896 amperes; total ampere hours 608,384;* number of cells during the greatest part of the time 16, and during a short period 15, the average being 15.97. As the cells were connected in series, the theoretical amount of nickel deposited would be equal to the product of the numbers of cells (15.97), the number of ampere hours (608,384) and the electrochemical equivalent of bivalent Ni in grams per ampere hour (1.09); this would give 10,590,000 grams, or 10,590 kg, while the amount of nickel actually deposited was 9,898.9 kg, or 93½ per cent. of the theoretical amount; the actual consumption of power was 5.3 horse-power hours per kg.

The difference of the power consumed in the deposition of the copper and the nickel is considerable. The weight of copper deposited from Cu_2 Cl_2 per ampere hour is about twice that of nickel deposited from NiCl2 per ampere hour, while the actual voltage is twelve times smaller for the copper than for the nickel, hence the energy required for the deposition of copper in this process is twenty-four times smaller than for nickel for equal weights of deposits. The nickel deposited in the Browne process has excellent mechanical properties, while data concerning its remarkable chemical purity were given above.

In the tower which contains a quantity of copper-nickel shot of the same weight as the anodes, the electrolyte for the process is produced; for this purpose chlorine is supplied from the nickel depositing cells and the sodium chloride from the evaporator; a proper quantity of water and a small quantity of hydrochloric acid is added; the shot is thus dissolved and the solution is supplied to the copper depositing cells as was described above. An addition of HCl is here necessary, because some additional chlorine is required for the formation of the electrolyte, while hydrogen escapes. This will become clearer from the following considerations.

For this purpose we may consider the additions to the solution during the different steps of the process. After the solution has passed out of the copper depositing cells, sodium sulphide is added, the sulphur combining with the copper of the cuprous chloride, while the sodium remains as sodium chloride in the solution. Later sodium hydroxide is added, the iron is precipitated as hydroxide, while new sodium chloride is formed in the electrolyte. Hence, in two steps of the process, sodium is substituted for the copper and the iron in their chloride solutions. If in the evaporator all the sodium chloride is separated from the solution its quantity will be somewhat greater than the amount of sodium chloride which was supplied to the shot during its solution in the beginning of the process. This surplus of NaCl comes from the Na, which was added in form of NaOH and Na_2S, and from the chlorine ions which were present, and as the chlorine undergoes a cyclic process partly free and partly in combination, it follows that there would be a deficiency in chlorine at the end of a cycle if a quantity HCl was not supplied to the shot, equivalent to the amount of Na in the added quantities of NaOH and Na_2S. These quantities are small because the amounts of Cu_2Cl_2 after the solution has left the copper depositing cells, and the amount of iron in the solution are small. Hence only a relatively small amount of hydrochloric acid is required.

The Browne process solves two problems. The one is the

* In Dr. Haber's report this figure is twice given as 60,834, but this is evidently a typographical error.

separation of copper and nickel in copper-nickel matte; the process may, therefore, be used as a substitute for the Orford process, and gives a considerably purer nickel than the latter does. The second problem solved will become clear, when we omit the copper depositing cells and the tower with the shot, and start with $NiCl_2$ with or without sodium chloride. This $NiCl_2$ would have to be produced from nickel sulphide or raw nickel metal in a special operation; then the process represents a method of electrochemically refining nickel, yielding as a by-product chlorine which would be changed to bleaching powder. The commercial situation in the United States and in Canada does not seem to be unfavorable to an application of the process in this form; there is no longer competition with the Orford process and there would be a market for the amount of bleaching powder. Suppose that the total nickel produced in the United States—about 4000 tons—would be produced electrochemically, then 5000 tons of chlorine or 14,000 tons of bleaching powder per year would be obtained as a by-product. In 1900 the import of bleaching powder into the United States amounted to 62,000 tons. Moreover there should be ready market for bleaching powder in the flourishing paper and pulp mill industry of Canada.

Dr. Haber then makes a general remark on electrometallurgical processes. The suggestions for industrial electrolysis of aqueous solutions are very numerous; the number of processes used in practice, however, is small. It is very often found that electrochemical methods are commercially too expensive compared with the older metallurgical methods. The reason of such failures is very often found to be an oversight of *the fundamental fact that the success of industrial electrolysis of aqueous solutions is mainly a question of maintaining the solutions pure during electrolysis.* We may express this in a somewhat exaggerated form by saying that everything can be accomplished with pure solutions, nothing with foul solutions. For the successful operation of the nickel process described the careful preparation of a pure nickel solution was of importance; for the Betts lead refining process it is of importance that the electrolyte dissolves impurities only to a very small degree. For copper refining the possibility of continually renewing the electrolyte is essential. It very often happens that a process which operated well with pure materials in the laboratory, failed at a large scale because the electrolyte became soon impure and its purification required cost and difficulties which had not been expected in advance. This point is generally more important than refined construction details of the apparatus. True, it is without any doubt of importance for an electrolytic process, if by a suitable arrangement of the apparatus some electric power may be saved. But the essential point which decides the suitability or unsuitability of a process for operation on a large scale is found in the chemical side of the problem, and the principal chemical problem is that the initially good electrolyte should be maintained pure with cheap chemical means and with as little labor as possible.

Dr. Haber then describes the manufacture of carbon bisulphide in the electric furnace, as operated by E. R. Taylor in Penn Yan, N. Y. (Electrochemical Industry, 1902, Oct., p. 60, 63, 76). The electric resistance furnace used there is said to be nicely and suitably arranged in many respects, while the operation is simple and effective. Finally some notes are given on the mining of sulphur by the Union Sulphur Co., by means of the pumping process of Herman Frasch, as operated in Louisiana.

Dr. Haber concludes his report by some general remarks. Neither in the United States, nor in Europe electrochemical industries arose from the science of physical chemistry, but after these industries have been built up, the advantages which a thorough training in physical chemistry may give to an electrochemical engineer, become more and more evident; hence the desire of the practical engineer to acquire and utilize theoretical knowledge; this desire is even more conspicuous in the United States than in Germany. While theory does not give in general the first impetus to new technical processes, yet it is the more useful by aiding the experimenter to review and understand the difficulties which are to be overcome and to save valuable time which, without theoretical knowledge, would be wasted in an absolutely useless desire to overcome existing laws of nature.

While the general chemical industry in the United States has grown up in connection with the older development in European countries, this is not the case with various electrochemical industries which were built up independently of European practice. True some electrochemical processes have been introduced to America from Europe, among them the Goldschmidt tin process, and the storage battery industry. Dr. Haber also counts the mercury cathode methods for electrolyzing brine among the processes imported to America from Europe. Although Hamilton Young Castner, the founder of this important industry, is an American, yet the mercury cathode process was invented after he had taken his residence in England, and his process achieved its great commercial importance first in Europe, after Castner and Kellner had become co-workers.

As the first of the great electrochemical industries which were developed in the United States, the aluminium industry is mentioned. It is the result of the work of Charles M. Hall, who, in 1886, found the proper electrolyte which is the essential foundation of the process. His invention was not a complete one in the first moment, as another important point had to be recognized, i. e., the necessity of avoiding external heating and of using the heat of the current for melting the bath. In the United States this point has never been looked upon as so important as it is considered to be abroad, and Hall has emphasized that it was a self-evident development to avoid external heating when larger cells were used, and the observation was made that the heat of the current alone at a moderate voltage was sufficient to keep the electrolyte in fused condition. Dr. Haber remarks that if this might be doubted, yet this second point of invention is also to be placed to the credit of an American, Charles S. Bradley. His internal heating patent and Hall's invention of the electrolyte give together a complete picture of the essential points of the aluminium process. References are made to the litigation between the Pittsburgh Reduction Co. and the Cowles Electric Smelting & Aluminium Co., and to the work of Héroult and Kiliani, who, independently, developed the aluminium industry in Europe.

Two other Americans, Eugene H. Cowles and Alfred H. Cowles, were the first to fully recognize the importance of electric resistance furnace operations for metallurgical practice. Some notes are quoted from the final court decision by which the novelty of the invention of the Cowles Brothers is recognized. The inventors themselves have not developed their invention on a very large scale, as their time was absorbed by patent litigations.

Others have built up the large electrochemical industries based on the application of the electric furnace methods. The most notable inventor in this line is Edward Goodrich Acheson, whose highly important work is represented by the industries of carborundum and of artificial graphite.

The series cell system in copper refining and the splendid development of the multiple system are also American accomplishments. The same is the case with the Acker process for electrolysis of sodium chloride, although the idea of using molten lead for absorbing the sodium was adopted from Europe. Finally the calcium carbide industry in which Thomas L. Willson was the pioneer was developed independently of European practice.

While America has thus achieved important successes independently and simultaneously, partly ahead of Europe, there are, on the other hand, other electrochemical industries in which Europe was or is ahead of America. The Griesheim (diaphragm) process for eletrolytically producing caustic alkali and chlorine was in successful operation when LeSueur

was still experimenting in Rumford Falls in Maine.* The sodium hypochlorite apparatus for textile mills, which exist in various suitable types in Germany and Austria, have not yet been introduced in the United States. There have not yet been developed in this country electrochemical industries of zinc or chromium salts, nor the electrochemical preparation of permanganates and of silicium and of organic compounds. Dr. Haber is surprised that carborundum has not yet found more applications in Europe; while diaphragm processes for electrolyzing brine are used to considerable extent in paper and pulp mills in the United States, this is not yet the case in Germany. On the other hand he remarks with surprise that ozone apparatus (ELECTROCHEMICAL INDUSTRY, 1903, Jan., p. 179) for sterilization of water have not yet been introduced in the United States where there should be a good field for them, in view of the fact that the drinking water in many American cities is very bad.

Dr. Haber recommends to carefully study the American electrochemical patents and suggests that visits from Germany to the United States for studying the commercial conditions in this country should be more numerous. He recommends especially that German manufacturers should be represented by fine exhibits at the St. Louis Exposition next year. This should be the case, especially in organic chemistry; he considers that the leading position of Germany in organic chemistry is based on the high development of scientific organic chemistry and the thorough scientific training of young chemists in Germany.

* Dr. Haber mentions in a foot note the "bell process" used in Aussig, which is a process without diaphragm, the anode and cathode solutions being automatically held separate by gravity. He remarks that this process apparently requires bells of small size, so that for an operation on a large scale many small apparatus would be required, which would, of course, be a disadvantage.

CRITICAL NOTES ON DR. F. HABER'S REPORT ON ELECTROCHEMISTRY IN THE UNITED STATES.

CHEMICAL EDUCATION IN THE UNITED STATES AND GERMANY.

BY THEODORE WILLIAM RICHARDS.

Dr. Haber's report was highly interesting to me, and I am glad to say a word about his discussion of chemical education. On the whole, I agree with Dr. Haber's criticism, both favorable and unfavorable. That much time is lost in our college preparatory schools, and that this loss is due partly to the restless spirit of our nation, I cannot doubt. It must be granted, also, as Dr. Haber asserts, that too much of our teaching deals with knowledge as if it were complete, instead of in the process of growth. I quite agree with his praise of our methods of teaching elementary chemistry in the laboratory. I do not think that he makes it quite clear that the courses in chemistry which he quotes lead only to the degree of bachelor of science, and that the doctor's degree in America usually requires three years more of original work. Much of the work which forms a part of these scientific school undergraduate courses is counted toward the doctor's degree in Germany. The confusion caused by this difference in classification makes it a difficult problem to compare the value of the degrees in the two countries.

With Dr. Haber's unqualified opinion concerning the practical importance of physical chemistry I emphatically agree. Whether the present theories advanced by this branch of the science are transitory or permanent, it seems to me that knowledge both of its subject-matter and of its method is essential as well to the manufacturer as to the investigator in any branch of chemistry.

HARVARD UNIVERSITY.

AMERICAN AND GERMAN UNIVERSITIES.

BY JOS. W. RICHARDS.

In the technical part of Dr. Haber's paper I have noticed extraordinary assiduity in collecting facts, and clearness in stating them, so that the report forms, in this respect, one of the best general reports on the condition of the electrochemical industry in America which has ever been written. I note some places, however, where he has practised "the scientific use of the imagination," to fill up gaps in his information, and sometimes with results far from the truth.

In the discussion of our university and technical school instruction, Dr. Haber is usually correct in his statements, but his information is more fragmentary than concerning our electrochemical industry. He studied the later pretty thoroughly; the former, necessarily, only partially. His conclusions as to the low entrance requirements for our universities, and the low plane of undergraduate instruction given in them, may be true of those which he visited and describes, but is founded on too hasty and fragmentary a study of our universities and technical schools as a whole, to give much value to his generalizations, and really does grave injustice to some of our best institutions. I should say that it is impossible for even so keen an observer as Dr. Haber to give an entirely just opinion of our system of higher education as a whole, with less than six months' study of the subject here in America. Some of Dr. Haber's criticisms are true, some are only partially so; that is, they are true only of the institutions which he particularly chose for examination, and so do not apply unreservedly to all our universities.

After all, Dr. Haber would criticise us, as compared with Germany, for the relative absence of the deeper philosophical and theoretical studies and the preponderance of eminently practical subjects. On the other hand, we might reply by criticising the relative absence of the latter in the German universities. The golden, well-balanced mean between the two schools, between academic pedantry, on the one hand, and narrow commercialism, on the other, is the goal toward which our best institutions are tending, and toward which they are advancing more rapidly and more hopefully than the European universities.

LEHIGH UNIVERSITY.

THE TEACHING OF PHYSICAL CHEMISTRY.

BY ALEXANDER SMITH.

I have, indeed, little criticism to offer in regard to Dr. Haber's report. I agree in the main with almost everything he has said.

As regards the teaching of chemistry, and particularly the teaching of physical chemistry, I think the most important thing in the report is the part in which he draws attention to the difference between the old and the new chemistry. The instruction in chemistry, as it is given almost universally, both in Germany and in the United States, is strictly from the structural chemical standpoint. The composition of compounds and its expression in formulæ, the valency of elements, and the quantitative analytical methods of determining chemical proportions, are the things upon which most stress is laid. The real chemistry of the factory, of the laboratory, and of nature, on the other hand, is something enormously

broader than this. The study of physical chemistry is rapidly enlarging our knowledge of the conditions under which chemical changes occur, and consequently the results of physical chemistry cannot be excluded from any instruction in chemistry, from the most elementary to the most advanced. The illustrations which Dr. Haber gives, such as the manufacture of sulphur trioxide by the contact method, illustrate this. The materials to be used and the proportions, indeed, have long been known, but while chemical instruction of the prevailing kind regards these as the most important facts, it turns out that the labor and study required to determine the exact conditions under which this action may be carried out unfailingly and continuously, really represented by far the greater part of the task.

It is our duty to teach, not the chemistry of the past, but the chemistry of the present, and even, so far as may be possible, to anticipate the chemistry of the future, since our pupils are to form the chemists of the future. Whether, therefore, we teach formal physical chemistry or not, the results of physical chemistry and the spirit of physical chemistry must be indispensable features of modern instruction in every branch of the science.

University of Chicago.

FIXATION OF NITROGEN FROM THE AIR.

By Charles S. Bradley,
President Atmospheric Products Co.

Dr. Haber's criticisms of the process of the Atmospheric Products Co. are, of course, largely correct. The Atmospheric Products Co. did not have a large plant in working operation at the time that Dr. Haber made his visit. We are trying to avoid the making of mistakes on a large scale, therefore we are operating single units until such time as we shall be absolutely certain that no changes are necessary. This method of developing new business is quite novel, as heretofore nearly every concern has been run into large operations at a too early date in order to avoid just such criticisms as these of Dr. Haber's; these criticisms tend to injure the commercial development, and therefore the inventor is always very anxious to reach the large manufacturing stage; this, however, should be approached with caution. Our capital being assured, it is not necessary that we should try in any manner to produce impressions on the public.

As to the platinum-iridium electrodes, platinum only is used, not iridium, and, as Dr. Haber says, "the experience has proved that the wear and tear is negligible," and we feel sure that there is no possibility of a greater rate of wear and tear during long periods of time than that heretofore observed.

As to the doubts that Dr. Haber expresses as to collection and conversion of the fumes into the various merchantable products, we would say that these are all provided for at a very low cost, and that the power is the principal item of expense in the operation; there is room, however, for a large profit after all expenses are paid.

Niagara Falls, N. Y.

THE IMPORTANCE OF THE PURITY OF SOLUTIONS IN COMMERCIAL ELECTROCHEMISTRY.

By David H. Browne.

"Alles ist mit reinen, nichts mit unreinen Laugen zu erreichen." This generalization, by Dr. Haber, shows more than any minutiæ of detail his understanding of commercial electrometallurgy.

The difference between copper refining in the reverberatory and in the plating bath is not so great as appears on the surface. In the first case all the labor and cost is devoted to getting one percent of impurity volatilized or slagged off. Not till all the foreign elements are removed can any pure copper be obtained. In the other case all the labor and cost is spent in carrying over ninety-nine per cent. of the pure metal and the dropping of one per cent. impurity is simply an incident. Carry the copper-plating to such a point that some copper commences to plate in an impure state, and we are in exactly the same condition as the melter with his furnace full of blister copper; we can obtain no more pure metal till all the impurities are removed.

We have, it is true, the elective affinity of the current to aid us—just as in the Patterson or Parks process we have the crystallization of lead or the melting points of zinc alloys to aid us in the removal of silver. But just as the commercial importance of these processes depends upon our not pushing these selective tendencies of nature to their limit, so does the commercial importance of an electrical process depend on our keeping well within the selective tendencies of the electric current.

As Dr. Haber says, it is this neglect to keep initially good conditions permanently good which consigns so many promising processes to the scrap pile. Close experiment will almost always reveal the proper conditions under which certain work can be done—but the continuance of these conditions is attainable only by continual vigilance, which is as much the price of liberty as it is the price of success.

Copper Cliff, Ont., Can.

THE "SERIES" VS. THE "MUTIPLE" SYSTEM IN ELECTROREFINING.

By Woolsey McA. Johnson.

It is with some diffidence that I approach this subject, for I have done but little work in this subject for some time: At present I am working out in an oil reverberatory furnace, so designed as to allow of a temperature constant to 10° C., the various conditions of temperature, rabbilng character of flame as shown by gas analysis for the common reactions of roasting, chloridizing, and smelting. This furnace will be described at another place. However, when engaged in the subject of the electrorefining of crude nickel I made a careful study of the question of the series and multiple systems, and will give below some of my conclusions.

For nickel refining the "series system" presented, to my mind at first, several manifest advantages, viz.:

(1) No "starting sheets" required.

(2) The "one-piece" electrode holds up the scrap, and reduces the percentage of scrap to below 20 per cent., as against 50 to 60 per cent. in the multiple systems.

(3) Connections are diminished, and high voltage used.

The advantages on experimenting did not prove to be what was at first expected, for I found that it was perfectly possible to make "starting sheets" cheaply on sheet iron cathodes. Strangely, Mr. Thum, Mr. Browne and myself independently came to the same conclusion, that the sheets should be annealed.

Next, Mr. Hybinette, superintendent of the Orford Copper Co., when I was in its employ, devised a cheap furnace treatment for the production of nickel anodes, of such composition that the scrap was reduced to a low figure (about 15 per cent.). Consequently I considered that the advantages of the series system for nickel refining were reduced to vanishing point.

Also, it is a fact that in the multiple system the anode is dissolved on both sides. Consequently, metal tied up in vats for same current density is double that of multiple system, and interest charge would be also double. On maturer reflection, looking at the question from the perspective of a year, it seems to me that there is very little to choose between the two systems for a nickel proposition.

This is just about the case with copper refining, and some collateral evidence proves it. At Baltimore the two systems are used side by side, the series for high grade, rich bullion that can be rolled, and the other for low-grade bullion that is not malleable. The fact that much less metal is tied up in the vats in copper refining (quite the contrary to the case in

nickel refining) cuts down interest charges. The cost of rolling, etc., balances the two systems.

The only other refinery that uses the "series" system has intimate commercial relations with another refinery that uses the "multiple" system. These relations are so close as to lead one to believe that profits are pooled, or that both are controlled by the same interests. These two refinieries are both now in operation, as has been the case. Were there any great advantages of one system over the other, one refinery would be closed and remodeled. As a matter of fact, the plant using "multiple" system is being enlarged at the present time.

The above facts were pointed out to me by an extremely able metallurgist who is "en rapport" with the commercial conditions in the copper business. For plain and obvious reasons his name is not mentioned.

In my opinion the advantages of one system over another for either copper or nickel are just the advantages of measuring a length in centimeters or inches. The distance is the same whatever the unit be. A person would use that system of measuring to which he is accustomed. I believe, to meet the general conditions of copper refining, the "multiple" system to be the simpler and better.

HARTFORD, CONN.

Besides the above articles, some shorter notes on various subjects of Dr. Haber's report were received:

MR. LAWRENCE ADDICKS, of the Raritan Copper Works, Perth Amboy, N. J., makes some remarks on the series versus multiple system in copper refining. He points out that "over 70 per cent. of the copper now refined in the United States is treated by the multiple system. The various refineries differ but little in the essentials of the process employed, the points of difference being in the methods of handling details. It is not so much what is done, as how it is done."

MR. LOREN R. VORCE, of Cleveland, Ohio, formerly with the Baltimore Copper Works, gives a note concerning the addition of a small quantity of salt (NaCl) to the electrolyte, which was introduced in the Baltimore plant several years ago. "I have always regarded its supposed beneficial results as more imaginary than real. This for two reasons. First, the Baltimore plant made, from the same anodes, and with the same electrolyte (practically), just as good copper before the practice was begun as it has ever made since. Second, I have made, myself, equally good copper without the use of NaCl."

MR. ANSON G. BETTS, of Lansingburgh, N. Y., states that he will read a paper on electrolytic lead refining before the American Institute of Mining Engineers, and that this paper will contain data that answer some of the criticisms made by Dr. Haber.

MR. HERBERT H. DOW, General Manager of the Dow Chemical Co., in Midland, Mich., states that they are unable to give any additional information on their plant, which is of peculiar interest for several reasons, as pointed out by Dr. Haber (ELECTROCHEMICAL INDUSTRY, June, p. 351). The plant has at the present time an annual capacity of about 20,000 tons of bleaching powder; they also manufacture the bulk of the bromides used in the United States, and other chemicals in a less extensive way. They are able to secure unlimited quantities of brine on their property, and coal is found within five miles from the plant.

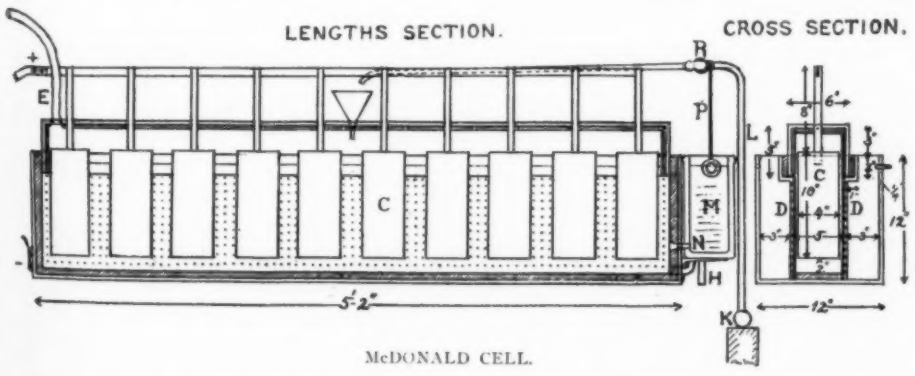
SYNOPSIS OF ARTICLES IN OTHER JOURNALS.

A Summary of Articles on Electrochemistry and Allied Subjects Appearing in American and Foreign Periodicals.

BY CARL HERING.

INDUSTRIAL ELECTROLYSIS.

McDonald Electrolytic Alkali Apparatus.—In the *Eng. and Min. Jour.*, May 26, T. ULKE describes the construction of an electrolytic apparatus for the production of chlorine or bleach and caustic soda, constructed by McDonald and in operation at the Clarion Paper Mill at Johnsonburg, Pa. As will be seen from the adjoining cut, the cell consists of an iron tank, 1 foot wide and high, and 5 feet 2 inches long, which is cast in one piece, with two longitudinal partition walls, thus dividing it into three compartments. These partition walls are perforated, and against each perforated side wall of the central compartment, which forms that of the anode, there is stretched a diaphragm, consisting of a layer of asbestos paper fastened to asbestos cloth by a small quantity of sodium silicate. This diaphragm is held in position by cement, placed over both end walls and the bottom of the anode compartment. The latter is closed by a cast iron cover, 5 inches deep, 6 inches wide and nearly 5 feet long, into which the anodes are cemented. It is painted inside with asphalt varnish and lined with cement. The anodes consist of blocks of graphitised carbon, 4 inches square and 10 inches long, into each of which a copper rod is fastened by means of lead, to serve as connection for the current. The anodes are connected in multiple. The cathode is formed by the tank itself, or rather by the partition walls. The perforations in the partition walls are about one-thirty-second of an inch in diameter, and there are about 4 or 5 of them to the square inch. The partition walls are flanged, so as to form a seat for the reception of the cover, and for a layer of cement, which extends completely around the cover and hermetically seals the joints between it and the end and partition walls of the tank. A lead pipe leads from the anode chamber to a gas main of vitrified pipe, which carries the chlorine gas to absorbing towers, where it is brought into contact with lime water. Elbow pipes carry the caustic solution out of the cathode compartment. The brine is fed into the



McDONALD CELL.

anode compartment by an automatic feeder. It is stated that a plant has been in operation at the Clarion paper mill since the spring of 1902. The present installation consists of 50 McDonald cells, arranged in two parallel rows and occupying a floor space of about 60 by 15 feet. The author states that it appears that with a current of 420 amperes and 225 volts (4.5 volts per cell) there are 1400 pounds of chlorine produced daily. This figures out, according to him, to 167.5 electrical horse-power for 2.5 tons of bleach, or 67 horse-power per ton per day, or nearly 10.5 pounds of chlorine per horse-power day. Mr. McDonald, says the author, confirms that a ton of bleach does not cost him over $12 or $15 to produce, even without counting the value of the caustic liquor and hydrogen obtained as by-products. It is stated that the McDonald cell will be employed, as soon as the necessary equipment can be secured, by the Standard and Colorado City chlorination works in Colorado, which plants are said to have a combined daily capacity for heating 700 tons of gold ore, and are paying $45 per ton of bleach. This installation, says the author, according to report, will eventually comprise 500 cells, costing with royalty $50,000 complete, and located in a building approximately 200 by 200 feet. The caustic liquor from the cells is said, according to Mr. McDonald, to average 3 to 4 per cent. salt, and about 16 to 18 per cent. NaOH, and is wasted at present. Attention may be called in this connection to a patent by McDonald of an anode for electrolytic apparatus, which is described in Electrochemical Industry, Vol. I., p. 190. The anode proposed there is composed of strips of platinum, preferably 10 inches long and 2 inches wide, for an apparatus of the dimensions mentioned in the above article. According to the above it does not seem to be used, however.

Electrolytic Production of Metals.—H. A. Frasch, in the *Electroch. Zeitsch.*, for June, gives under this title what is virtually an extract from his patent, No. 720,235, of February 10, 1903, which was noted at some length and illustrated in the Analysis of Current Electrochemical Patents in the March number of Electrochemical Industry, p. 252.

Electric Furnace Methods of Iron and Steel Production.—John B. Kershaw begins a series of articles under this title in the issue of June 6 of the *Elec. Rev.* In the present issue the Conley, Héroult, Keller and Kjellin furnaces are described. This first installment does not seem to contain anything new.

The Electric Furnace, Its Origin, Its Development and the Forms of Its Application.—Under this title Adolphe Minet, the well-known inventor of the Minet aluminium process, and publisher of *L'Electrochemie*, begins in the June number of the *Electrochem. Zeitsch.* a series of articles. A number of illustrations of the various furnace constructions are given.

Copper Ores.—It seems from *Engineering*, May 1, that there is evidence that in Northern Rodesia and in Central Africa there is an enormous wealth of copper ore awaiting only the construction of a railway to be made readily available. It is believed that Africa will in a few years become the world's greatest source of supply of copper. Some reports of Farrell are quoted.

THEORETICAL AND EXPERIMENTAL.

Metallic Diaphragms.—The question of metallic diaphragms is getting to be of considerable practical importance. Among the apparatus in which they are used, are that of Garuti for the manufacture of oxygen and hydrogen, and the Castner sodium apparatus, in the first of which a perforated sheet of iron is employed as diaphragm, and in the second a wire-gauze diaphragm. Buffa has proposed the following theory as far as Garuti's apparatus is concerned: "The perforated plate behaves like a diaphragm, if the tension of the electrodes is smaller than the double amount of the voltage of decomposition of the electrolyte. This theory is exact only when the metallic plate forms a complete dividing wall and separates the electrolyte into two parts, which do not communicate with each other." This statement is not very clear. The phenomena which appear with metallic diaphragms have been studied among others by Kaufmann, Danneel, Barillet and Brochet, the latter of whom, in an article in the *Zeitsch. f. Electrochemie*, gives some further experimental data on the subject. The apparatus used consisted of two ebonite frames, between which the platinum diaphragm plate was clamped. Two metallic plates which formed the sides of the apparatus, serve also as electrodes. The platinum electrode had a hole in the middle, and when the plate is acting as diaphragm, the current passes entirely through the hole. This takes place at a certain current density, while for lower current densities there is a certain equipotential circle, inside of which the plate acts as diaphragm, and outside as bipolar electrode. The diameter of the hole has, therefore, a decided influence on the result, but the form of the hole has no influence on the form of the equipotential line, except very close to the hole. If the plate has a certain number of holes, each of them behaves similarly, and to each belongs an equipotential circular line. The influence of the resistance of the electrolyte is similar to that of the current density. If the conductivity of the electrolyte is decreased, the equipotential circle becomes smaller. The author arrives at the following conclusions: The principal condition is that the material of which the diaphragm consists is not attacked by the electrolyte either before or after electrolysis; the plate will act the more perfectly as diaphragm; that is, will have the less inclination to take part in the reaction, the higher the voltage of decomposition of the electrolyte. Apart from this the good working of the diaphragm depends upon the following conditions: (1) Small diameter of the perforations; (2) the total surface of the perforations must be as large as possible relatively to the surface of the metal; that is, the perforations must be as numerous as possible; (3) small thickness of the plate; (4) good conductivity of the electrolyte. Finally, when the diaphragm is very thick, the resistance of the metal has to be considered. A part of the above article was also presented before the French Academy of Sciences, and abstracted in *L'Industrie Electrique*, May 25.

Electrolytic Production of Persulphates.—Though considerable work has been done in the matter of producing persulphates by electrolysis, not much is known about the question, to what extent different temperatures of the electrolyte influence the yield of persulphate obtainable. Data as to the influence of the material, of which the electrodes are composed, on the result of the electrolysis, were also very meagre. The appearance of a communication on this subject, by Levi, in the *Gazetta Chimica Italiana*, abstracted in the *Zeitsch. f. Electrochemie*, May 21, is therefore a welcome contribution to the literature on this subject. Ammonium sulphate was used as starting material and electrolysis was conducted with anodes of bright sheet platinum. The cathodes used in the different experiments were of platinum, nickel, lead and carbon, and the anode was always arranged between two equally distant cathodes. The electrolyte was kept weakly alkaline, and the cell was placed in a thermostat during the experiments bearing on the influence of the temperature. The interesting result was found that the yield of persulphate obtained was unchanged up to 30° C., and that it does not begin to fall off until 40° C. is reached. Up to now it has been considered quite essential that the electrolysis should be conducted at a low temperature, which is evidently disproved by the results obtained by Levi. The experiments with cathodes of different material showed that the lowest yield was obtained with lead, and the highest with carbon, though the differences were not considerable. The physical structure of the platinum anodes, however, had considerable influence on the result. Variations in the current density of not too great an extent were also shown to have no influence on the result.

On the Electrolysis of Alkaline Sulphides.—In *Comptes Rendus*, Vol. 136, Brochet and Ranson give their experiments on the electrolysis of alkaline sulphides. They confirmed the results of former investigators, that in dilute solutions of this kind the sulphide is transformed into sulphate. But if the

operation is carried out with a concentrated sulphide solution, heated to 50° to 70° C., the process is quite different. Then only sulphur is formed at the anode, while caustic soda and hydrogen appear at the cathode. The sulphur thus liberated dissolves in the concentrated sulphide solution to form polysulphides, and the colorless liquid becomes yellow. But as the solution tends to become richer in sulphur, the latter combines with the cathodic hydrogen and regenerates the sulphide. In this way the two inverse reactions are obtained, $Na_2S + 2H_2O = 2NaOH + H_2 + S$. The authors have also noticed a phenomenon previously described by Koelichen, namely, the oscillation of the needles of the volt and ampere meters, due to the deposition and successive solution of a minute layer of sulphur on the anode. Electrolysis was conducted by the authors with and without diaphragms.

Electrolytic Reduction of Chlorate of Potassium.—A note was recently presented to the French Academy of Sciences referring to recent experiments of Bancroft, Barrows and Brochet, and describing some earlier experiments made long ago by TOMMASI, in which he arrived at substantially the same results. If a solution of potassium chlorate, acidulated with sulphuric acid, is electrolyzed, there is obtained, according to the nature of the anode, an oxidation or reduction of the chlorate. With platinum electrodes there is a formation of perchlorate at the anode, without any trace of chloride at the cathode. If a platinum cathode and a zinc anode are used chloride of potassium is produced at the anode, but there is no reduction of the chlorate at the cathode. "The reduction of this compound in this case cannot be attributed to the hydrogen, but to the zinc, which on combining with the oxygen of the chlorate to form oxide of zinc, would reduce the chlorate to chloride." It is the same when chlorate of potash is reduced by zinc and dilute sulphuric acid, in which case the transformation of the chlorate into chloride is said to be due, not to nascent hydrogen, but to the combination of the zinc with the oxygen of the chlorate. If a solution of chlorate, not containing any sulphuric acid, is electrolyzed, a white precipitate of hydrate of zinc is obtained at the anode. The perchlorate of potassium treated under the same conditions as the chlorate, undergoes no reduction, even when a zinc anode is used. He also observed the reduction of potassium chlorate under the following conditions: If granulated zinc is introduced in a solution of copper sulphate containing this chlorate, the mixture, after a few minutes, becomes heated to such a degree that it soon boils, and the whole of the chlorate is transformed into chloride, while part of the copper passes into the condition of cuprous oxide. Chlorate of potassium is also reduced by the action of zinc on mercuric nitrate or nitrate of lead, by the action of tin or iron on copper sulphate, etc., but it is not reduced by sodium amalgam in neutral alkaline or acid solution. In the presence of dilute acetic acid, zinc does not reduce the chlorate, but the zinc-copper couple reduces it partially. The note is published in the *Journ. de l'Electrolyse*, May 15.

Reduction by Means of Carbides.—The question of what reaction takes place when metallic oxides and mixtures of metallic chlorides and oxides are reduced by calcium carbide, has been discussed at some length between Neumann and von Kuegelgen in the *Chemiker Zeitung* and the *Zeitschrift fur Electrochemie*. The former maintains that the reaction taking place is expressed by the equation, $M''Cl_2 + 2M''O + CaC_2 = 3M'' + CaCl_2 + 2CO$. In this case a primary formation of carbon monoxide would have taken place. Von Kuegelgen holds that the reaction takes place according to the equation $M''Cl_2 + 4M''O + CaC_2 = 5M'' + CaCl_2 + 2CO_2$, and that carbonic acid is the primary product. In order to strengthen his position VON KUEGELGEN publishes some further experiments on this point in the *Zeitschrift fur Electrochemie* of May 14. The experiments were conducted in an atmosphere of nitrogen, and the gases set free were aspirated and analyzed. The apparatus consisted of a tube of difficultly fusible glass, which was introduced into a combustion furnace. The mixture was contained in a tube of somewhat smaller diameter, which was introduced into the first, in order to prevent the destruction of the combination tube by the reacting substances. It was found, if a mixture was made of PbO and $PbCl_2$, according to the quantities $PbCl_2 + 4PbO + CaC_2$, that no CO was present in the escaping gases. If the mixture was made according to Neumann's proportions, $PbCl_2 + 2PbO + CaC_2$, up to 6.2 per cent. CO were found. A yield of 93.3 per cent. of metal was obtained with the first proportion. A mixture of $CuCl_2$ and CuO in the two above proportions gave up to 13 per cent, and up to 17.2 per cent. CO, respectively. No CO was found in the reduction of CuO alone. The formation of the above quantity of CO in the former case is explained by the very violent reaction which takes place. If the violence of the reaction is diminished by the addition of sand, the percentage of CO in the gases was cut down to 1.4 and 1.8 per cent. A mixture of $CuCl_2 + 4NiO + CaC_2$ gave 5.2 per cent. CO, while $CuCl_2 + 2SnO_2$ on the contrary showed up to 15.96 per cent. CO. Von Kuegelgen explains this latter by the fact that oxide of tin is much less reducible by carbon than the two other oxides, and that, therefore, more CO must be formed in spite of the lower temperature, $Cl_2 + 4CuO$ gave no CO. Von Kuegelgen concludes from these experiments that the combustion of the carbon in the oxychloride reduction depends on the one hand on the violence of the reaction which takes place in the reduction of the chloride by the calcium of the carbide, and on the other hand upon the easy or difficult reducibility of the oxide. The feebler a chloride acts, the more inclination there is to form carbonic acid with the easily reducible oxides; the stronger it acts, the less is this inclination. Only chloride of silver and chloride of copper, which act so much stronger than other chlorides, can occasion the formation of carbon monoxide, and the latter is not considerable, even with chloride of copper, which reacts stronger. By the addition of sand it was nearly completely suppressed. The more difficultly an oxide is reducible, the more inclination exists toward the formation of carbon monoxide. All this is claimed by von Kuegelgen, but these experiment with mixtures of the composition $PbCl_2 + 4PbO + CaC_2$, where he found no CO present, stand in direct opposition to Neumann's results in *Zeitsch. f. Electroch.* 8, 774, where the latter found 45.5 per cent. CO from a mixture in the same proportions.

On Alkali Carbides.—In a short article in the *Electrochem. Zeitsch.*, June, 1903, MOISSAN, after a short historical summary of the methods of carbide formation, describes the production of the carbides of rubidium and cæsium. If a wire of cæsium or rubidium is embedded in absolutely dry lamp black, and the whole is heated in a vacuum tube, the combination of the metal with the carbon takes place when the temperature is slowly increased. After cooling there is found a small molten mass in the middle of the carbon, which, when brought into contact with water, produces a violent generation of acetylene gas; consequently carbide was formed, but it was not pure. The combination of the metals with the carbon was not complete, because a part of the carbide was decomposed on account of the heat set free in the reaction. It follows, therefore, that the production of the carbides of rubidium and cæsium will be more difficult than that of calcium or lithium carbides. These two carbides will decompose at a temperature which is much nearer to their temperature of production than is the case with the carbides of the alkaline earths. The carbides of rubidium and cæsium were, however, obtained by Moissan with the help of another method, namely, by starting from the ammonium compounds of the two metals. These new compounds are easily obtained by acting with liquid ammonia on the metals; thus the compounds $C_2Cs_2C_2H_2$ and $C_2Rb_2C_2H_2$ are formed. These crystallized compounds were then heated in a vacuum tube and the temperature was gradually increased, which resulted in the formation of the carbides.

Electrochemical Reduction of m. Nitroacetophenone and m.

Nitrobenzophenone.—In order to determine whether, and in what way the carbonyl group takes part in the reduction during the reduction of nitroketones, Elbs and Wogrinz subjected m. nitroacetophenone and m. nitrobenzophenone to electrolytic reduction in alkaline and acid solutions. The experiments are described in the *Zeitsch. f. Electrochem.*, May 21. A sheet of lead in sodium carbonate solution served as anode for the reduction of the m. nitroacetophenone in alkaline solution, and a nickel wire gauze of 1 sq. decimeter surface, as cathode. The results obtained show, that m. nitroacetophenone is easily reduced by the electrochemical method to m. azoacetophenone and to m. aminoacetophenone. The experiments on the production of m. azoxyacetophenone always furnished mixtures of the azoxy and the azocompound; the reduction to the hydrazocompound and its rearrangement to the corresponding benzidin did not succeed very well. M. nitrobenzophenone furnishes by electrochemical reduction m. azoxybenzophenone, m. azobenzophenone and m. aminobenzophenone, with very good yield. The hydrazocompound is very easily oxidizable and the benzidin, which is obtained from it, has properties which are unfavorable for its purification. A taking part of the carbonyl group in the reduction could not be proved in the various electrochemical methods which were used for the reduction of the nitro group.

The Electrochemical Reduction of Various Stilbene Derivatives.—In order to ascertain whether the well-known dye stuff "sun yellow" is in the main azoxystilbenedisulphonic acid, Elbs and Kremann subjected it to electrolytic reduction in alkaline and acid solution. For the experiments in alkaline solution the apparatus consisted of a tall beaker glass, with a porous cylinder as anode compartment, cold saturated caustic soda as anode solution, and an anode of lead, while the cathode was formed by a cylinder of nickel wire gauze. For the experiments in acid solution the anode liquid was 10 per cent. sulphuric acid. The following results were obtained. Sun yellow, p. azostilbenedisulphonic acid and also p. dinitrostilbenedisulphonic acid furnish in the electrochemical reduction in alkaline solution p. azotoluoldisulphonic acid as final product; the ethylene bond is broken and the azo group, which has been reduced to the hydrazo group, is reformed by the oxygen of the air. P. dinitrostilbene furnished by electrochemical reduction in alkaline solution p. azoxystilbene, in acid solution according to Boehringer's patent p. diaminostilbene. Under the same conditions p. dinitrodibenzyldisulphonic acid furnishes p. azodibenzyldisulphonic acid or p. diaminodibenzyldisulphonic acid. In the reduction of sun yellow, according to Boehringer's method there are obtained p. diaminostilbenedisulphonic acid and p. toluidenesulphonic acid; under the same conditions p. dinitrostilbenedisulphonic acid furnishes essentially only p. diaminostilbenesulphonic acid. The authors conclude from the results of these experiments that the dye stuff is essentially composed of p. azoxystilbenedisulphonic acid. Their researches are described in the *Zeitsch. f. Electrochem.*, May 14.

Electrolytic Synthesis of Sugars.—An account of experiments made by Walther on the electrolytic synthesis of sugars is given in the *Chemiker Zeitung*, 1902, Aug. 16 and Oct. 18, translated in *Engineering*, May 1. The chief interest lies in their great simplicity. He starts with carbonic acid, generated from marble and hydrochloric acid and passed through water. The current density being of great importance, he applies as anodes brushes of platinum wire 0.2 millimeter in diameter, the wire ends being all at equal distances from the cathode. The cathodes have a very large surface and are made of platinum, silver, mercury, iron, etc., and by preference of "clay, aluminium silicates." A red clay, containing some ferrous oxide, is mixed with the oxide Fe_3O_4, or with carbon, or with both, and the mass is smeared on iron wire gauze, yielding a cathode of high resistance. A clay pot serves as diaphragm, and the anode compartment is sometimes heated with the aid of a small incandescent lamp, so that the temperature of the anode solution remains about 5° C. higher than that of the cathode solution. The experiments were conducted in two parallel series: In the first, the solution of carbonic acid gas in water alone is used; in the second, certain salts, chiefly ammonium sulphate or phosphate, and also vegetable albuminoids, were added. The results did not differ in principle, although they depend much on circumstances. The electrolysis commences when the water is saturated with carbonic acid. The e. m. f. and current are gradually raised, by increasing the cathode surface, heating the anode compartment, and in other ways. Oxalic acid first makes its appearance; then tartaric acid is formed, and soon citric acid. When the general conditions favorable to the formation of citric acid are maintained and the current slowly raised, the appearance of carbohydrates is noticed: fruit sugar first, finally grape sugar. The sugars thus produced are optically active in the saccharimeter, although the rotary power was not quite so high as it ought to have been. Attention is called to the fact that the compounds produced become richer in carbon as the current and e. m. f. rise. Walther considers the phenomena essentially as oxidation and reduction processes, and it is pointed out that the electric current affords a very convenient means for bringing about certain reductions and oxidations which must proceed under that careful control which the regulation of current, e. m. f., concentration, temperature, etc., in the electrolytic cell enables one to maintain. "Electrolytic processes are more widely applied, especially in organic chemistry, probably, than is generally believed; chemical manufacturers are not very communicative." Some general remarks are added on the relations between electrochemistry and thermochemistry, and on the applicability of chemical ideas to life phenomena.

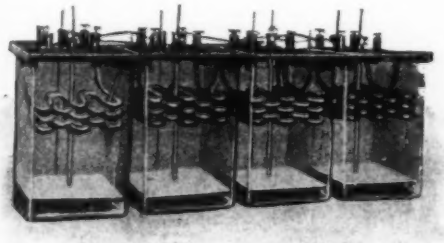
Electrolysis of Potassium Silicate by Alternating Currents.—Th. Gross in the *Electrochem. Zeitsch.* for June, gives the results of some experiments of the electrolysis of potassium silicate, dissolved in an aqueous solution or in a melt of potassium hydrate. An alternating current of 120 volts and 30 to 40 amperes was conducted through solutions of one part silica, two to four parts potassium hydrate and five parts of distilled water. The mixture was introduced into a silver dish, which served as one electrode. The other electrode was formed by a small silver crucible. Soon after closing the circuit the whole liquid colored brownish-black, and at the smaller electrode a moderate evolution of gas took place, which could be checked for a time by moving the electrode. Gradually there was a brownish-black body separated from the liquid. After continuing electrolysis for several hours, and introducting the resulting mass in much water, a greyish-black precipitate was obtained. The results obtained, according to the author, show that silicic acid disappears in the electrolysis by alternating current, and that instead of that a new body is obtained, which is not a compound of the ingredients of the materials used. When one part silica and five parts potassium hydrate were fused and electrolyzed in the same manner as above, a white flocculent body was obtained. In so far as the results said to be obtained are concerned, it must be said that a transmutation of elements, as is inferred in the above, would, indeed, be very surprising, and upset all our theories. As far as trustworthiness of results obtained by the author is concerned, it may be remembered that some years ago he came out in print, claiming that he had obtained by electrolysis a new element from sulphur, for which he proposed the name bythium. His experiments were repeated by Alexander, who gave exact quantitave figures, and were absolutely disproved. We will therefore do well to wait for some further proofs before we change our chemical theories.

Crystallization in the Electric Field.—Reasoning from the fact that a globe-shaped crystal body in a homogeneous electric field, if it has complete liberty motion, will tend to so arrange itself that the direction of the greatest dielectric constant coincides with the direction of the lines of force. Schmidt thought that if crystals would separate out in an electric field from a solution, they would assume a fixed direction. Experiment did not prove this supposition, but it was found that the crystals

only deposited at one electrode, while the other remained free. The substance used was sulphur, dissolved in a solution of carbon bisulphide. The electric field was maintained by an influence machine with about 40,000 volts difference of potential between two brass electrodes of 3 x 7.5 cm surface. A layer of sulphur crystals had formed on the anode at the end of the experiment, while the cathode had no deposit on it at all. For further details see *Phys. Zeitsch.*, June 1.

PRIMARY AND SECONDARY BATTERIES.

Electromotive Force of the Daniell Cell.—Chaudier published in *Comptes Rendus* of last year a number of measurements on the Daniell cell, which apparently were in direct contradiction of the Nernst theory, in so far as he found a maximum of e. m. f. at a concentration of $\frac{1}{2}ZnSO_4\ 7H_2O$ in 100 grams water. The values obtained by him decreased from this maximum with increase in the $ZnSO_4$ concentration of the solution. The theory of Nernst would have required, however, that a decrease of e. m. f. should take place with increasing $ZnSO_4$ concentrations. As such a result as that obtained by Chaudier would have far-reaching significance on the theory of the subject, the experiments were repeated by COHEN and COMMELIN, and their results are published in the *Zeitsch. f. Electrochem.*, May 21. Their experiments were carried out with the greatest care, and with an apparatus so constructed that not the slightest diffusion of the copper solution to the zinc electrode could take place, as it influences the electromotive force of the system to a large degree. The authors proved first that a saturated zinc solution at 15° C. contains 150.65 grams $ZnSO_4\ 7H_2O$ to 100 grams of water, while Chaudier gives 200 grams. The difference is unexplained. The measurement of the e. m. f. shows that Chaudier's results were wrong, and that there is no contradiction between the actual experiments and the theoretical requirements, according to Nernst's equation. The e. m. f. decreases with the increase of concentration and a maximum at $\frac{1}{2}ZnSO_4\ 7H_2O$ does not exist.



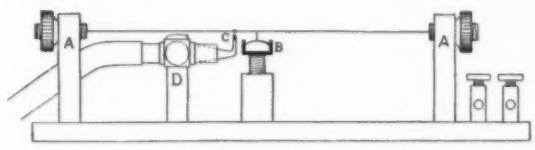
ELECTROLYTIC RECTIFIER.

Oxydation and Reduction Potentials.—SCHAUM and VON DER LINDE publish in the *Zeitsch. f. Electrochemie*, May 7, their results obtained in the measurement of electromotive forces with mixtures of various amounts of ferro and ferricyanide of potassium. The measurement was performed, according to the Poggendorff-DuBois Reymond compensation method, with an Ostwald rheostat and a Lippmann capillary electrometer with vertical capillary. The average results agreed well with those calculated from the Helmholtz and Van't Hoff formulas. The authors also made measurements of potentials of mixtures of sodium sulphite and potassium sulphate, but do not give the results, as no definite conclusions could be drawn from them. Series of experiments which were conducted under exactly the same condition very often showed considerable deviations.

GENERAL AND MISCELLANEOUS.

Electrolytic Rectifiers.—A new contribution to the subject of electrolytic rectifiers of alternating currents into continuous current is contained in an article by GRISSON in the *Electrotechnische Zeitschrift*, June 4. The author cast about for means to suppress the generation of hydrogen at the aluminium plate, which is used as electrode, as he had noticed that the destruction of the coating of alumina by hydrogen when the plate was acting as cathode was the main source of the breaking down of the apparatus. He solved this problem, in a physical way, by arranging a lead plate horizontally on the bottom of a glass vessel and fixing an aluminium plate parallel to it a short distance above, as shown in the accompanying illustration. When the aluminium plate now acts as a cathode, bubbles of hydrogen accumulate at the weak places, but these bubbles offer so much resistance to the current that only a small part of it passes through these damaged spots, and there is time for a new protecting layer of alumina to form beneath the gas bubble. There is also a cooling coil of lead pipe arranged in the upper part of the solution, in order to keep the electrolyte from getting hot. An average efficiency of over 60 per cent. was obtained. The formation of the protecting layer of alumina takes place best when a low current density is used.

Interrupter for Conductivity Determinations.—The Kohlrausch method for the determination of the conductivity of electrolytes depends, to a large extent, upon the proper working of the interrupter, which should require no further watching after it is once regulated, and it should be possible to change its frequency, if desired. A device, proposed by C. W. KANOLT, described in the *Zeitsch. f. Electrochemie*, May 14, is designed to overcome various difficulties met with in the operation of interrupters. It depends upon blowing a current of air from a small orifice against a small globe, secured to a wire which



INTERRUPTER.

is stretched between two points and the tension of which can be regulated in order to change the speed of vibration. It is shown in the accompanying illustration. A small platinum rod is fixed near the globe, which makes contact with a mercury receptacle, the height of which can also be varied. One terminal of the circuit, which is to be interrupted, is connected to the wire, and the other to the mercury. The interrupter is said to work well, if the air is blown against the globe with one-third to one-half atmosphere pressure.

Wiesberg.—A detailed illustrated description of the hydroelectric plant of Wiesberg, in Tyrol, is given by STOEGER in the *Elek. Zeit.*, May 14. The plant is situated near the place where the Trisanna and Rosanna Rivers combine to form the Sanna River. The plant is mainly destined to furnish electric power to the electrochemical works at Landeck. For the operation of the electric furnaces single-phase alternating current would have been best, but in view of the motor load, and of a prospective traction load, three-phase current at 40 periods per cycle was chosen. The alternators give three-phase currents at 12,000 volts, which is the voltage of transmission. Three 1,000-kw generators have been installed and there is space for three more. In the electrochemical works of Landeck, calcium carbide, pure silicon and silicon copper are made, and it is intended to also undertake other electrochemical work.

The Development and the Present Status of Electrochemistry is the title of a long, illustrated article, the first installment of which appears in the June number of the *Electrochem. Zeitsch.* The author is the editor of that journal, DR. NEUBURGER. The matter in the present issue is purely historical, leading from the very beginning of electrochemistry up to about the year 1806. This broad historical treatment is to be

the basis from which to arrive at an unbiased judgment, if the present method of investigation is on the right road to lead to an extension in breadth and in depth in the physical and electrochemical field. The author proposes to discuss that matter exhaustively. In view of Dr. Neuburger's well-known standpoint with regard to the present predominating school of physical and electrochemistry in Germany, it will be interesting to read what he has to say about the subject.

Electrochemical Laboratory.—A description of the equipment of the electrochemical laboratory of the University of Grenoble, France, is given in the course of a long, illustrated article by Barbillion in *L'Eclairage Electrique*, May 23. The equipment consists of a dynamo with separate excitation, giving 350 to 400 amperes at 7 volts. There is also a large storage battery which can give 2,500 amperes for various experiments and the testing of industrial apparatus.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

By George P. Scholl, Ph. D.

Apparatus for the Electrolytic Production of Metals and Compounds.

Apparatus for the Continuous Practice of Electrolytic Processes. Pedro G. Salom, Philadelphia. Patent 727,457, May 5, 1903. Application filed September 17, 1902.

The invention relates to an apparatus by means of which, without interruption to the process, the material which is to be acted upon may be continuously supplied to an electrode, and also by means of which a product which is formed at an electrode may likewise be continuously removed. Though applicable to other processes, it is probably primarily intended for the carrying out of Mr. Salom's lead reduction process, as employed by the Electrolytic Lead Reduction Co., of Niagara Falls. As is well-known the process consists in the reduction of galena by hydrogen ions in the electrolysis of dilute sulphuric acid. Hydrogen sulphide is evolved at the cathode, and oxygen is set free at the anode. The apparatus is illustrated in the accompanying Fig. 1 in central vertical section. It is mounted on a wooden table A. The cell proper consists of an annular body B, of a trough-shaped cross section, with inner and outer peripheral walls *b b*. It is composed of antimonial

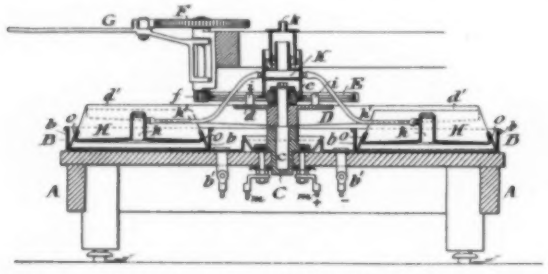


FIG. 1.—APPARATUS FOR CONTINUOUS ELECTROLYSIS.

lead and is made a cathode by means of the connection *b' b'*. The anode consists of a series of segmental plates H, supported by the spider frame D, and bridging the spaces between seven of the eight arms of the spider frame, the space between the seventh and eighth arm being left open. Current connection to the anode is made through socket C and upright post *c*. The anode can be rotated by mechanical means, as shown in the figure. In order to prevent the escape of gases anywhere else but through the pipe *h*, both of the peripheral surfaces of the ring formed by the anode segments are provided with rubber petticoats *o o*, which sweep against opposite walls of the cell B. A box which is filled with the material to be acted upon is arranged in the open space between the spider frames above referred to, and is provided with a feeding slot, by which a continuous stream of material, the thickness of which can be varied, is fed to the bottom of the cell. A scraper-plate is also arranged, which, as the annular anode rotates, sweeps the spongy mass out of the apparatus. The process, according to the inventor, presents the following advantages: The galena may be spread very thinly and evenly over the cathode This results in very complete reduction. It makes possible the use of larger current densities—60 amperes per square foot of cathode surface—which hastens the reduction process. Being continuous, there is no loss of time contingent upon the removal of the electrodes in order to get at the product. There are no dangerous and injurious effects upon the workmen as are experienced when they have to handle and remove the electrodes.

Electrolytic Apparatus. F. J. Briggs, Everett, Mass. Patent 727,889, May 12, 1903. Application filed May 21, 1902.

The present invention has for one of its principal objects to accomplish decomposition of the salts of the alkaline metals, without loss of electrolytic action by reason of leakage or diffusion of the hydrate of the metal through the diaphragm into the anode compartment, and vice versa. This the inventor seeks to overcome by the use of two floating anode compartments, which he calls dialyzers. The apparatus is divided into two equal parts by an iron petition, which serves at the same time as auxiliary cathode. Each of the sections thus formed contains a floating anode compartment and a vertical cathode. The anode compartments are composed of frames, lined internally with a diaphragm, which consists of an outer sheet of perforated iron, an inner sheet of asbestos paper, and an intermediate sheet of asbestos cloth. A series of carbon anodes is arranged in the anode compartments. There is a complicated arrangement of pivoted levers, at one end of which is fastened the floating anode compartment of one section of the apparatus, while the cathode of the other section is supported by the other end of the lever, and vice versa. By this means the inventor claims to regulate the liquid in both compartments in such a manner that it will practically stay at an even height, after it once has been adjusted. The troubles incidental upon the diffusion of the anodic into the cathodic solution, or vice versa, if the level in one of the compartments falls too low, are thus stated to be obviated.

Electrolytic Cell. Hugh K. Moore, Lynn, Mass. Patent 728,274, May 19, 1903. Application filed August 29, 1901.

The application deals, not so much with an electrolytic cell, as with a method of fastening copper conductors into carbon anodes. In casting the end of the carbon into a lead backing, a difficulty has been found, in so far as the resistance of the cell increases gradually. This the inventor has found to be due to the porosity of the carbon, which permits the aqueous solution to work up by capillary attraction, and to form by precipitation a dry non-conducting layer between the carbon and the lead, thus greatly increasing the electrical resistance at that point. It is prevented by the following construction: The carbons, which have a low coefficient of expansion, are bored to form a socket for copper rods of a high coefficient of expansion. Between the copper and the carbon a bushing of a material of high conductivity is placed, which has a coefficient of expansion between that of copper and carbon, and is not affected by chlorine. Platinum, iridium, etc., may be used. The heat generated by the passage of the current, it is claimed, causes the expansion of the platinum into firm con-

tact with the carbon and similar contact of the copper with the platinum. This way of fastening may be all right, but would run up the expense tremendously on a practical scale.

Cathode Holder. Joseph Mathews, of Birmingham, and W. Davies, of County of Worcester, England. Patent 727,549. May 5, 1903. Application filed March 29, 1901. Divided April 21, 1902. Renewed March 5, 1903.

The patent refers to a cathode holder for electrolytic and similar purposes, especially for removing the tin from tin-plate scrap. It consists of a cell, made of terra-cotta or porcelain, not affected by electrolytic action, which is open at the side and is provided with a trough-shaped receptacle at its lower end to catch whatever tin falls from the electrode.

Electrolytic Separation of Copper and Nickel from Mattes or Ores. E. A. Sjoestedt and J. H. James, of Sault Ste. Marie, Canada, assignors to F. H. Clergue. Patent 725,998, April 21, 1903. Application filed September 20, 1901.

The copper-nickel matte (preferably concentrated), or ore, is crushed to a powder and roasted. This is then treated with a 40 per cent. boiling-hot sulphuric acid solution for eight to ten hours. This dissolves the iron, copper and nickel. The undissolved excess may be heated with fresh acid a second time. The liquor thus obtained is cooled and mixed with water, just sufficient to redissolve again the salts which have precipitated during cooling. This liquor is electrolyzed with copper cathodes and platinum, graphite or other insoluble anodes, in order to deposit the copper, starting with a current of normal density of 0.3 ampere per 100 square cm. of cathode surface. When the copper deposit begins to look dark and impure, the solution may be run off to treat fresh matte, since the acidity has decreased by the copper being deposited. Heat is applied as before, more of the matte is brought into solution, and the electrolysis and extraction is repeated as often as profitable. Finally, to deposit the copper in an adherent form, the current is gradually reduced as the deposit shows signs of becoming dark and loose. When no more copper can be deposited in a satisfactory form, the cathodic current density is reduced and electrolysis continued as long as any copper is deposited, or, if necessary, the last trace of copper may be removed by filtering the solution through a filter of nickel sulphide or iron sulphide. The electrolyte is kept agitated by a current of air during the electrolysis.

The copper having all been removed, the remaining liquor or solution is nearly neutralized with caustic soda, then made ammoniacal, the iron oxidized by a blast of air (preferably air rich in oxygen) and the precipitated ferric hydrate filtered off. The drawn-off liquor, being neutral or but slightly ammoniacal, is now subjected to an electric current of normal density of 0.6 to 0.9 ampere per 100 square cm. of cathode surface, nickel cathodes and graphitized carbon, or other insoluble anodes being used, the solution kept agitated by a current of air sufficiently heated to keep it at a temperature of 80° to 90° C., when the nickel is deposited.

Apparatus for the Treatment of Gold or Other Ores. W. B. McPherson, Los Angeles, Cal. Patent 725,864, April 21, 1903.

The apparatus consists of a series of tanks for treating the ores of the precious metals with cyanide solution, and to facilitate the action of the solvent by keeping the ore charges agitated. They are finally discharged into precipitation boxes where the solution is electrolyzed between iron anodes and copper cathodes. The arrangement and construction of the various boxes are described in detail. Means are also provided for keeping the level of the solution in the precipitation tank at a constant height by a float contained in a receptacle which is connected by a pipe with the precipitation tank, and actuates several valves in the bottom of the tank. No details as to the manner of carrying out electrolysis, current density, etc., are given.

Production of Chromium Compounds and Alkalies. H. Specketer, Griesheim-on-the-Main, Germany, assignor to Chemische Fabrik Griesheim Electron, Frankfort-on-the-Main. Patent 728,778, May 19, 1903. Application filed July 1, 1901.

The process consists essentially in subjecting the solution of one or more alkali metal salts to electrolysis, with an anode of chromium or a chromium alloy, or by using salts of chromium as an electrolyte with an insoluable anode, the anode electrolyte being separated from the cathode electrolyte by a diaphragm. Hydroxides or carbonates are added for the purpose of precipitating the alkali metal salt with the chromium and neutralizing the free acid which is formed with the chromic acid. For instance, with an electrolyte of sodium sulphate, an anode of ferrochromium (as obtained in the reduction of chrome iron ore by carbon) may be used; when electrolysis takes place with a diaphragm, after calcium carbonate or caustic lime has been added to the electrolyte, the following reactions take place: In the cathode compartment caustic soda is formed as usual. In the anode compartment free chromic acid, free sulphuric acid and ferric sulphate are formed, but undergo the following transformations:

(1) $2FeCr + 9SO_4 = Fe_2(SO_4)_3 + 2Cr(SO_4)_3$.

(2) $Cr(SO_4)_3 + 4H_2O = H_2CrO_4 + 3H_2SO_4$.

(3) $H_2CrO_4 + H_2SO_4 + 2Ca(OH)_2 = CaCrO_4 + CaSO_4 + 2H_2O$.

(4) $Fe_2(SO_4)_3 + 3Ca(OH)_2 = Fe_2(OH)_6 + 3CaSO_4$.

(5) $CaCrO_4 + Na_2SO_4 = Na_2CrO_4 + CaSO_4$.

The impurities pass into the precipitate and are separated by filtration, while the sodium chromate remains in solution, which is evaporated to dryness or transformed by means of sulphuric acid into sodium bichromate. The operation is conducted as follows: Into the cathode compartment, containing an iron cathode, there is introduced a saturated solution of sodium sulphate, while a 25 per cent. solution of the same is put into the anode compartment, with a quantity of caustic lime sufficient to neutralize 100 grams of chromic acid per liter, and a corresponding quantity of iron. The anode is ferrochromium and the voltage is from 2½ to 3 volts, with a current density of 1½ to 2 amperes per square dm. When the concentration of chromic acid reaches about 100 gms. per liter, the solution is removed, the oxide of iron and the gypsum filtered off, and the solution evaporated to crystallize the sodium chromate. A solution of chromium sulphate or chromic-iron sulphate may be used as electrolyte, either neutral or acid.

Oxidizing Organic Compounds. Martin Moest, Hoechst-on-the-Main, Germany, assignor to Farbwerke vormals Meister Lucius and Bruening. Patent 729,502, May 26, 1903. Application filed September 4, 1902. Divided March 11, 1903.

The inventor has found that cerium compounds under certain conditions are powerful oxidizing agents for organic substances. The ceric compounds are thereby converted into cerous compounds, but are at once reconverted by the current into ceric compounds. Exceedingly small quantities of cerium compounds need to be used. The process is illustrated as follows: (1) *Oxidation of Anthracene.*—A vessel lined with lead, serving as anode, contains sulphuric acid of about 20 per cent. strength, with preferably 2 per cent. of cerium sulphate dissolved in it. Any metal not attacked by the electrolyte may serve as cathode. The anthracene is introduced into the vessel while rapidly stirring, and the mixture is heated to about 70° to 90° C. Then the current is passed, which is maintained at a density up to 5 amperes per square dm., a tension of 2.9 to 3.5 volts being required. The current may vary within wide limits. Toward the end of the operation the temperature is raised to about 100° C. The process is complete, when the electrolyte keeps the yellow color of the unreduced ceric sulphate. The quinone thus obtained is filtered off and the filtrate may be used for another operation. The yield of anthraquinone per ampere-hour is nearly quantitative, and the product obtained is of excellent quality. (2)

Oxidation of Naphthalene.—The finely ground naphthalene is introduced into an electrolyte composed as above and contained in a similar vessel. The temperature is maintained at 40° to 60° C., and the current density is about 1 to 2 amperes per square dm. As soon as the coulombs, corresponding to the quinone, have passed the electrolyte, the current is interrupted, and the quinone thus formed, containing still some unoxidized naphthalene, is filtered. The electrolyte contains also some phthalic acid. If phthalic acid is chiefly to be obtained, the operation has to be continued in proportion. (3) *Oxidation of phenanthrene.* In the manufacture of phenanthrenequinone the process is the same as for naphthalene. It is preferable to employ a somewhat more concentrated cerium sulphate solution. If the current quantity calculated to the quinone is employed, and the temperature maintained at about 50° to 60° C., then chiefly phenanthrenequinone is obtained. If the action of the current is contained, the oxidation leads, besides other products, finally to benzoic acid.

Storage Batteries.

Storage Battery. F. A. Feldkamp, Newark, N. J. Patent 726,272, April 28, 1903. Application filed July 8, 1902.

The plate in this battery is constructed of a sheet of lead foil about 0.004 to 0.01 of an inch in thickness. It is provided with active material by impregnating or painting parchment, paper, linen, felt, asbestos, etc., with red lead or litharge, as the case may be, and folding it around the plate, the whole being then pressed out and ironed flat to secure the necessary contact. The fabric-covered plates are then placed under the needle of a sewing-machine, and the whole stitched well together, thus not only uniting them, but securing a number of perforations, serving for the circulation of the electrolyte. The plate is then dipped into a solution of diluted sulphuric acid and then cleansed in water, after which it is introduced into dilute ammonia water, the purpose being to render the fabric and the threads non-attackable by the acid of the battery. Between each pair of adjacent electrodes is placed a separator of light, inactive material, preferably of interwoven strands of cane. At both ends there is placed an insulating plate, and an aluminium plate on the outside of it. Stay bolts pass through holes left in the plates for this purpose, and the whole unit of electrodes can be tightly compressed by screwing up these tie bolts. This compact arrangement prevents any buckling of the parts and the disintegration which is due to jarring, especially when the cell is used for automobile purposes. The cell is illustrated in cross-section in Fig. 2, which, however, is out of proportion, the width being much increased and the length considerably decreased. Here 1 signifies the jar, 4, 4 the lead plates, 6, 6 the impregnated tissue, 14 are the separators, 15 the end insulating plates, and 17 the aluminium plates above referred to. The way of connecting the electrodes is clearly shown. The battery is primarily intended for automobile use, for which it consists of 23 to 30 of such electrodes, as described above, in a battery cell weighing about 10 pounds, and having the dimensions of 2⅝ x 6 x 11 inches.

Secondary Battery. P. Figuccia, Boston, Mass. Patent 726,274, April 28, 1903. Application filed May 22, 1902.

The invention relates more particularly to the means for retaining the active material in pasty or other form. The grid or frame of the electrode consists of a top and bottom bar, which are connected by a series of parallel juxtaposed bars. These bars are made as double channels, so as to form long channels on opposite sides of the frame, into which the active material in pasty or pulverulent form is packed. Various modifications of this leading idea are described in the specification.

Process of Forming Accumulator Electrodes. G. J. Scott, Philadelphia. Patent 726,468, April 28, 1903. Application filed Feb. 28, 1903.

The forming process described by the author is said to consist in separating the accumulator electrodes during the forming operation by a current conducting baffle or partition, which is interposed between the electrodes in such a manner that it will enable electric current to pass directly from one electrode to the adjacent electrode through the current conducting baffle or partition, and will permit the electrolyte to pass from one electrode to the other, but will compel this passage of the electrolyte to be along devious or circuitous paths. The baffles are composed of carbon. The inventor states that it is important to have the baffle imperforate, as the utility of the process decreases very rapidly if the baffles employed in its execution are supplied with even small perforations.

Reversible Galvanic Battery. Thomas A. Edison, Llewellyn Park, N. J., assignor to Edison Storage Battery Co., Orange, N. J. Patent 727,117, May 5, 1903. Application filed October 3, 1902.

Mr. Edison states that his invention consists in the discovery that if an easily reducible metal like copper, mercury or silver is added to the iron or other active material in the make-up of an electrode for a reversible galvanic battery employing an alkaline electrolyte, better electrical contact between the particles of the active material is secured, so that the weight of active material will be reduced more than the

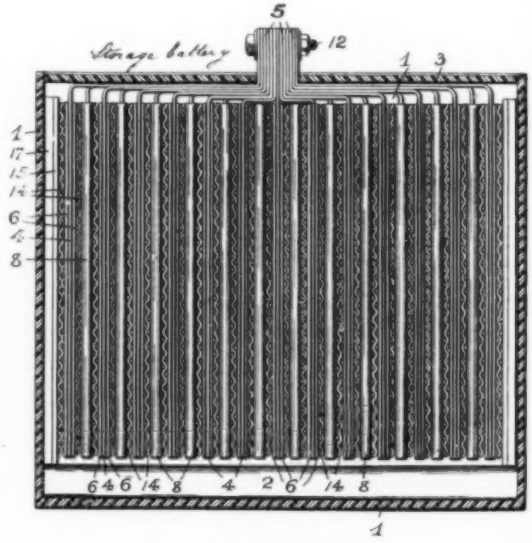


FIG. 2.—STORAGE BATTERY.

additional weight of the readily-reducible metal, while at the same time the cell will sustain a higher voltage through the entire period of discharge than would be the case if the readily reducible metal were not used. The preparation of the iron electrode takes place in the following manner: Finely divided oxide of iron is reduced by hydrogen, and when the temperature has been sufficiently reduced, water is forced into the retort to prevent the iron from oxidizing. After the surplus water has drained off, the iron is mixed with sufficient ammoniated copper to produce as final result a mixture of 66 per cent. iron and 33 per cent. copper, although these proportions may be varied considerably. The addition of the copper compound is stated to result in the copper being converted to the metallic state and a portion of the iron becoming oxidized, while ammonia gas is liberated. The mixture thus obtained may be immediately molded into briquettes and used in the battery, but preferably about 20 per cent. of foliated or flake graphite is added in order to increase the coherence of the mass and its electrical conductivity, and to render its manipulation more easy. An electrode of the above description forms one electrode of the battery, while a mixture of nickel hydroxide and flake graphite constitutes the other. A mixture composed of finely divided iron, with 15 per cent. precipi-

tated oxide of mercury, to which about 20 per cent. of flake graphite have been added, may also be used in place of the mixture containing copper, described above.

Plate for Electric Accumulators. Donato Tommasi, Paris, France. Patent 727,496, May 5, 1903. Application filed August 3, 1901.

The essential feature of the plate consists in the employment of strips placed in close proximity to each other inside of a lead frame. The strips of each adjacent group are arranged at right angles to each other, one group being vertical, and the other horizontal. These strips serve to retain the active material. A diagonal conducting strip is provided on one face of the plate in order to insure a uniform distribution of the current through all parts of the plates. Free circulation of the electrolyte is provided for by having a hole in the central strip of each group. Various constructions embodying the above idea are shown in the specification.

Storage Battery. A. W. Charlton, Toronto, Canada. Patent 728,202, May 19, 1903. Application filed October 6, 1902.

The electrode of this battery consists of perforated lead tubes, rectangular in cross-section. A core of lead, having four wings, which extend into the four corners of the rectangular tube, and are likewise perforated, serves to retain the oxide of lead or other active material. The tube is elongated, that is, has one pair of faces considerably wider than the other pair; the active material is thus divided into triangular prisms. Separators are used to keep the electrodes apart. The inventor claims that this construction will prevent buckling of the plates, due to unequal expansion.

Storage Battery. Mary Emmé, New York. Patent 728,381, May 19, 1903. Application filed March 11, 1902.

This construction solves the storage battery problem in a wonderfully simple manner. The positive and negative electrodes are put down in the ground, and "the earth between the electrodes belonging to each cell is moistened with a suitable (!) chemical preparation. A desired number of cells can be put down at suitable (!) distances in a piece of ground of suitable area. The cells thus constructed have the advantage of dispensing with vessels and insulating arrangements of ordinary storage batteries." It is a bitter reflection upon the sterner sex, that after so much of their brain power has been wasted in solving the storage battery question, a woman had to come and show them how to do it. Just think of the simplicity of going into the storage battery patch every morning and evening and sprinkle some electrolyte on the electrodes.

Storage Battery. J. C. Brocksmith, Chicago. Patent 728,667, May 19, 1903. Application filed January 14, 1902.

The invention consists in a storage battery, in which the grids comprise frames for supporting the active material and conducting rods embedded in the active material, and in which the plates formed of the grids and active material are spaced apart by washers made of insulating material, and being united by insulating rods passing through the plates and washers. The negative pole plate is only 75 to 80 per cent. of the thickness of the positive plate. The construction is described in detail.

Separator for Storage Batteries. E. D. Sperry, Cleveland, O Patent 729,100, May 26, 1903. Application filed November 25, 1901.

The separator is formed of a sheet or plate of hard rubber, vulcanite or gutta percha, provided with suitable corrugations and perforations. The corrugations are formed in the plate while it is being vulcanized. This procedure is stated to overcome the tendency of such plates to straighten out again, when the corrugations were made by passing the heated plates through metal rollers. Staggered projections are also provided on the plate in order to keep it away from the adjacent battery element.

Storage Battery. Robert Darling, Rye, N. Y. Patent 729,140, May 26, 1903. Application filed December 26, 1901.

This invention relates to the class of storage batteries of the positive element resting on the bottom of the cell. It consists of an amalgamated zinc plate. The negative element consists of comparatively thick plates of antimonious lead, between which are a number of thin sheets of lead which are primarily corrugated, and then firmly pressed together. The laminated element thus formed is bound together by bolts, and has numerous perforations. A number of units similarly constructed are combined, in order to form a plate of the desired size.

GALVANIC CELLS.

Connector for Electrical Batteries. W. R. Edwards, Weybridge, England. Patent 728,092, May 12, 1903. Application filed March 17, 1903.

The invention consists in an improved form of washer, interposed between the plates to be connected. It has projecting ridges upon both of its sides, which are forced against and into the plates.

Battery Chute. F. E. Paradis, Chicago. Patent 728,968, May 26, 1903. Application filed July 23, 1902.

This invention relates to improvements in storage receptacles for electrical batteries, especially when used underground. The objects of the invention are to provide a construction which protects the battery, so that it can be installed underground without danger of access of moisture or dirt, and to which access may be readily had without moving the receptacle. A mechanical construction is described in detail which embodies these features. Relief of any internal pressure is also provided for.

Electric Battery. E. Tweedy, New York; T. Roberts, Brooklyn; G. R. Tweedy, Danbury, Conn. Patent 729,240, May 26, 1903. Application filed May 22, 1900.

This invention relates to batteries of the type of double-fluid cells, and is particularly applicable, though not limited, to that type in which use is made of a "non-porous" diaphragm, patented by one of the inventors. Such a diaphragm is made by filling the pores of an ordinary porous cup with a gelatinized mineral substance, such as silicate of soda. The present construction aims at overcoming some difficulties met with in the operation of those cells.

MISCELLANEOUS.

Ozone Generator. G. L. Curtis, New York. Patent 727,101, May 5, 1903. Application filed January 17, 1903.

This ozone generator is a portable device intended for therapeutical and similar purposes. It consists essentially of a glass tube open at both ends, an exhausted tube mounted within that tube and insulated from it, and a metallic connection on the exhausted tube in contact with a wire leading into the interior of the tube. The apparatus is intended to be unipolar, the body of the person who uses it serving as the opposite pole. The metallic connection is attached to a current of high potential.

Apparatus for Purifying, Sterilizing or Ageing Liquids. R. C. Turner, Columbus, O. Patent 725,803, April 21, 1903. Application filed May 29, 1902.

The apparatus comprises a number of vessels of non-conducting materials, situated below each other, so that the spout of each upper one can discharge into a metallic funnel which leads into the next lower one. The funnels are connected in parallel with one pole of the current, while pieces of metal, placed on the bottom of each vessel, serve as the other pole, and are also connected in parallel. As the liquid flows into the first vessel, it closes the electric circuit from the funnel to the plate, and so on in the following vessels. In this way, the liquid as it flows down through the series of vessels in a small, continuous stream, is subjected successively to the action of electricity and air.

Purifying Apparatus. P. J. Boucher, Cleveland, O. Patent 728,440, May 19, 1903. Application filed October 16, 1902.

The apparatus consists of a metal pipe, lined on the inside with wood. Longitudinal grooves are cut into this lining, which support a series of aluminium plates, arranged horizontally and alternately in connection with the positive or nega-

tive terminal of a source of electricity. The liquid to be purified, water, for example, is said to become purified by the electrolysis of the anode aluminium plates, which form a flocculent insoluble aluminium compound, thus causing the impurities suspended in the liquid to coagulate and deposit. Provision is made for the easy withdrawal of the electrodes when they require to be cleaned.

Process of Treating Kaolin for the Production of Carborundum and Alumina. F. C. Weber, Chicago. Patent 728,528, May 19, 1903. Application filed November 3, 1902.

The process consists in charging kaolin, having the formula $Al_2O_3 + 2SiO_2 + 2H_2O$, into a reverberatory furnaces, and at 360° driving off the non-combined and chemically combined water. This process leaves the kaolin in the form of a klinker as anhydrous aluminium silicate, which is then ground to a coarse powder. This is then mixed with coarsely powdered coke in atomic proportions, to produce, when the mixture is subjected to the temperature of the electric arc, aluminium carbide and carborundum according to the following reaction: $4(Al_2O_3 + 2SiO_2) + 21C = Al_4C_3 + 4SiC + 14CO$. The resulting solid mass is thrown into a tank containing water, where the aluminium carbide is decomposed according to the equation: $Al_4C_3 + 12H_2O = 3CH_4 + 2Al_2(OH)_6$, forming methane and aluminium hydrate. The resultant aluminium hydrate is separated from the crystalline carborundum by subjecting the material to a washing and filtering process, by which the aluminium hydrate is washed out. The liquid containing it is then evaporated to dryness and the aluminium hydrate heated again in a reverberatory furnace, to make it anhydrous, after which it is treated in the usual way, in order to produce metallic aluminium.

CURRENT NOTES.

The Metallurgical Engineer in the Foundry.—In a paper presented at the recent Milwaukee meeting of the American Foundrymen's Association, Mr. Henry Souther, of Hartford, Conn., pointed out that a little money spent systematically for the services of a metallurgical engineer (not a chemist pure and simple) may save great sums. It is very much in the nature of an insurance against loss. Conditions may seem so favorable for months at a time possibly, materials may be received of such uniform and satisfactory quality, that money spent for expert services will appear to be wasted, and therefore the plan is discontinued. Then suddenly may be received shipments of coke or iron, which, had they entered the cupola, would have ruined at least one day's product before discovery, and the loss would have paid an expert for some time. This is not an imaginary occurrence, but a real one.

Mr. Souther excepts the chemist from this argument, for the following reason. A good chemist may be able to determine the amounts of the various elements in irons or fuels to the third decimal to the minimum limit of chemical error. He may be quick and do a large number of determinations per day. But of what use are results without practical interpretation and application? A chemist may become the best kind of a metallurgist, but only by personal contact with metallurgical operations in every detail and in several branches. A good share of common sense is a most valuable and necessary adjunct. A metallurgist need not be a chemist, but he must know how to use a chemist and the results obtained by the chemist. The chemist is an absolute necessity to the metallurgist. The steel industry is the most marked example of an industry thriving under the care of expert metallurgists assisted by chemists. The two are rarely united in one person, each being busy in his own field.

Rule of thumb methods gave way to exact methods about 1870 in the iron and steel industry to a marked degree. That which is common practice now would not be possible at all without the chemist to analyze under the direction of the metallurgist and with his interpretation of results.

It is no longer necessary for a foundry, large or small, to employ the exclusive services of a metallurgist. One may be found in nearly all the large manufacturing centers of the East or West, who is at the service of the general foundry trade on very reasonable terms. As a rule, these experts have their own chemical and physical laboratories; a necessity in nearly every problem under their investigation. One without the other is helpless. As a matter of fact, the chemist without that practical training and experience to which the author so strongly refers has blocked and retarded the advance of the use of expert knowledge into the foundry trade more than any one other element.

Every analysis the metallurgist should ask for ought to count in getting at results. A lot of good time and acid is wasted in determining the amount of graphite carbon in pig iron for cupola work. The total carbon is the only vital carbon result worth consideration in connection with iron to be used for melting.

The Faraday Society.—As was already briefly noticed in these columns, the newly-formed (British) Society of Electrochemists has adopted the name *"The Faraday Society*, to Promote the Study of Electrochemistry, Electrometallurgy, Chemical Physics, Metallography, and Kindred Subjects." The first ordinary meeting will be held on June 30. The proceedings of the Society will be published in *The Electro-Chemist and Metallurgist*. All papers presented to the Society will be printed and circulated among the members before being read, and, as a rule, they will be read in abstract only. Members and others unable to be present will be asked to send their contributions to the discussion in writing, and their remarks will be read out to the meeting. By this means it is hoped greatly to increase the value of the discussions, and to give absent members an opportunity of expressing their views. The Society shall consist of members and students, the subscription of each member being two pounds a year (about $10.00), and that of each student, one pound a year (about $5.00). Subscriptions are payable in advance on the first of January in each year. For the period from July 1 to December 31, 1903, the subscription is one pound (about $5.00) for each member. Members joining the Society before January 1, 1904, are exempt from paying an entrance fee. The Hon. Secretary of the Faraday Society is F. S. Spiers, 82 Victoria Street, London.

Mining in the Transvaal.—At the annual meeting of the General Mining & Finance Corporation, which owns a number of gold-mining properties in the Transvaal, held recently in Johannesburg, Mr. George Albu made some interesting statements on the re-establishment of the Rand mining industry after the war has been ended. Extensive repairs of machinery were necessary, but these have been undertaken with such an energy that nearly 95 per cent. of the mines which were working prior to the war, are now in a position to resume operation as soon as labor is obtainable. But great difficulties are involved in the solution of the labor question. The rate of progress now depends entirely on the supply of colored labor.

Hofman Medals.—The German Chemical Society has conferred its A. W. Hofman gold medals for this year to Prof. Henri Moissan and Sir William Ramsay.

A New Application of Electroplating.—A New York electroplating firm has recently introduced a new method of preparing wornout babies' shoes by electrodeposition. A heavy deposit of galvano bronze is first applied, and then there is plated on it either copper-bronze, oxidized silver, antique brass or gold; this preserves the shoes and turns them into a neat and original souvenir for the family, and an ornament for the curio cabinet. If the little toe is worn through and buttons are off or a seam ripped, they will look all the more natural.

Electrochemical Analysis.—The article of Mr. Ivar Juel Moltkehansen, in our June issue, contains two typographical

errors. On page 351 the second line from the bottom should read: It was found that the PbO_2 was more firmly deposited, etc. On page 352 the author refers to *Chemiker Zeitung*, Vol. 25, No. 37, not page 37.

CORRESPONDENCE.

ELECTROLYTIC CONDUCTION WITHOUT ELECTRODES.

To the Editor of ELECTROCHEMICAL INDUSTRY.

Sir: In your issue of June, page 343, bottom of second column, I noticed the statement that "This might give a method of measuring conductivity without the use of electrodes."

Exactly this method was used by Guthrie and Boys in 1880 to obviate the use of electrodes and the resulting polarization. If my recollection is correct, they rotated a magnetic cross within a chamber filled with the electrolyte to measure the resulting drag.

I regret that I cannot give you the exact reference.

NEW YORK CITY. WILLIAM M. GROSVENOR.

ELECTRIC FURNACE PROCESSES FOR MAKING IRON AND STEEL.

To the Editor of ELECTROCHEMICAL INDUSTRY.

Sir: In your issue of May last, Mr. Ruthenberg did me the honor of criticising an article written by me and published in your issue of April last. The criticisms made have not seemed to me to be of importance, but I would be discourteous did I not reply. The production, as claimed, of 500 kilowatt-hours at the cost of the consumption of 1,000 pounds of coal was denied by me under the following conditions, viz.: "Under *ordinary, continuous working conditions*" with coal *"burned under any kind of steam boiler."*

I have been unable to read the article published in *"Power, page 293,"* quoted by Mr. Ruthenberg, but I would at once submit that any test made after the manner such tests are usually made, would not fulfil the condition mentioned by me, viz.: *Ordinary continuous working.* Five hundred kilowatts are equal to 666 horse-power, 666 horse-power output from a generator (given an efficiency of 92 per cent.) requires the steam engine to indicate 724 horse-power. Such an engine consuming 1,000 pounds of coal would consume less than 1.40 pounds of coal per hour. Up to date this would be considered as being more than unusually good for *ordinary continuous working conditions* during *summer* and *winter.*

I will, however, state that were the cost of coal entirely eliminated from the calculation, a *good* water-power proposition, *properly* developed, could produce a *continuous* power more cheaply than can be done by the consumption of coal under a steam boiler and by the consequent use of steam, so made, in a steam engine.

I have little confidence in tests made by experts for the purpose of proving efficiency, unless such tests are backed up by proof, *obtained by actual work, under actual working conditions.*

As to the remainder the criticism, I can only regret that my English was not clear enough to enable Mr. Ruthenberg to grasp the point I, somewhat laboriously, endeavored to make.

That point was, that the commercial production of iron (viz.: pig iron, or iron in the condition in which it can be converted into steel,) from iron ores by the aid of an electric furnace, was not alone dependent upon the work of any one of the experts of the several different sciences involved, was not alone dependent upon the man who Mr. Ruthenberg designates as "selling steel," but that the commercial practicability of the process is dependent upon the existence of an average low cost of the several items which together make up the price, *paid by the consumer,* for the iron or steel delivered, and whether that cost be no greater, or whether it be less, than the consumer would pay for iron or steel of *equal quality,* when made by competing manufacturers, *using the old or any other process.* For myself, I do not care who or what he is, whether he be a scientist, who has given the commercial end careful and intelligent attention, or whether he be a plain commercial man, who has profited by the work and inventions of the experts, of any, or all, of the several sciences involved. *I argue, not to support men, but facts.*

I presume that Mr. Ruthenberg is willing to grant to the commercial man equal rights and privileges to those he claims for the expert scientist.

OTTAWA, CANADA. LOUIS SIMPSON.

BATTERY PRACTICE AND THEORY.

To the Editor of ELECTROCHEMICAL INDUSTRY.

Sir: In your commentary on the pamphlet which we issued, and of which Mr. Fay was the author, you state that Mr. Fay's remarks on the chemistry of the storage battery are not up to date, and that it is not correct to say that the chemistry of the storage battery is by no means understood, and in justification of your criticisms you point to the extended investigations of Dolezalek. We think you have misunderstood Mr. Fay, as he does not by any means mean that the chemistry of the storage battery has not been considered thoroughly by chemists, or manufacturers, or inventors, but what he does mean is that the chemistry of the batteries is not understood by those who are engaged day by day in handling the batteries, and we think that a careful investigation will justify what Mr. Fay claimed.

In his book he cites cases and gives absolute experiences of his own to prove that what he says is so, and we, coming in contact with many charging stations, etc., have seen cases where the experience has been just as Mr. Fay states, that, owing to the entire absence of a knowledge of the chemistry of the storage battery, batteries have been allowed to be ruined. As Mr. Fay cites, there are instances where batteries have been charged under iron beams; where the acid, etc., has been allowed to come in close contact with impurities; where the electrolyte has been allowed to be kept in service too long; where electrolyte has been used that has been made from substances other than that called for by the manufacturer of batteries, and, indeed, we could name a hundred, if not a thousand, different instances which would prove conclusively that the chemistry of the battery was undoubtedly not known. This is what Mr. Fay means, and it is true.

FRANKLIN H. KALBFLEISCH CO.,
By P. S. TILDEN, Vice-President.

NEW YORK CITY.

BOOK REVIEWS.

ELEKTRO-METALLURGIE DES NICKELS. By Dr. W. Borchers, Professor an der Kgl. Technischen Hochschule zu Aachen. Halle: W. Knapp. Price $0.55.

If we have any fault to find with this monograph it is with the excessive space devoted to practical methods used at the present time, and with the brevity with which the history of the subject is dismissed. Out of thirty-four pages, only fourteen are devoted to the pioneer patents to Berzelius of 1841, to Boetticher of 1843, to Bequerel of 1862 and to Adams of 1869. Hoepfner comes in for only three pages, which is remarkable, as in the Borchers' Electrometallurgy much more space is devoted to Hoepfner's demolishment. Poor Hoepfner is dead. Requiescat in pace. It was the writer's privilege to know him well: a brilliant man, eager, progressive, impetuous, impatient of the little details which were so often his undoing. Hoepfner was one of those daring pioneers who blazed a difficult trail ahead. If he wandered far in the forest, if he

stumbled often, let us who followed after, who found his ideas an inspiration, who put in practice what he saw in dreams and visions, let us be grateful for what he gave us. It had been a kindly act had Borchers given the praise that was Hoepfner's due.

But we digress. After discussing the patents of these men, after pulverizing the ideas of Strap, of Muenzing, of LeVerrier, of Frasch and Foerster, Dr. Borchers devotes forty-five lines to a description of the practical method of nickel-winning by fusion with alkaline sulphides. True, the details are all wrong, but as no details have been published since the Bartlett patents were issued ten years ago we can hardly blame Dr. Borchers for that. Forty-five lines given up to a process which makes only a million pounds of nickel a month is a graceful concession to the ignorant classes who want facts and not theories.

Coming down to present practice we find four or five pages devoted to a description of Ulke's process, which it is said is being installed by the Lake Superior Power Co., at Sault Ste. Marie. Through some unaccountable ignorance of the subject the Lake Superior Power Co. declare they do not know of having ever had any intention to install the same. Such lack of information is positively disgraceful. This news has been published time and again in the *Engineering and Mining Journal*, and has even appeared in Electrochemical Industry. Some one should really take the trouble to keep our manufacturers better posted.

To the work done in Dr. Borchers' laboratory by Dr. Guenther a scant fourteen pages are assigned. Guenther proposes to roast the nickel ores at a cost of from one to twenty pfennige, to smelt the roasted ore at a cost from 9 to 49 pfennige, and to concentrate this matte in converters at a cost from 6 to 15 pfennige per kilogram of metal. We cannot be too grateful for the accuracy with which the costs have been worked out. In order to separate copper from nickel in this matte he proposes to use the progressive method of Andre—patented in 1877—using copper sulphate as an electrolyte and obtaining nickel sulphate as an end product. This nickel sulphate is to be used as catholyte in a diaphragm cell with a lead anode in a solution of sodium chlorate. The resulting solution of lead is to be precipitated as lead chromate and sold as a pigment.

When we consider the simplicity of this idea and its innate superiority over the complicated scheme of Hoepfner's of splitting up nickel chloride into nickel and free chlorine, when we reflect that a two solution bath of this type is so easily constructed and that lead sulphate could by no possibility clog the pores of the diaphragm we wonder at the stupidity of our manufacturers in remaining oblivious to the many advantages of this process.

To those who can rise superior to the sordid considerations of commerce, who desire to know, not facts, but the elemental theories upon which all knowledge of the subject is based, the reviewer cannot too strongly recommend this pamphlet from the Royal Technical High School of Aachen. X. Y.

Laboratory Exercises with Primary and Storage Cells. By Karl E. Guthe, Ph. D. Ann Arbor, Mich.: George Wahr. 58 pages.

This small laboratory guide is intended to practically supplement the study of Carhart's "*Primary Batteries.*" The directions are very clear and elementary, and the exercises well arranged, and in this respect will undoubtedly be of considerable service to the author in his own laboratory class-work, and will be of assistance to others who wish to save the trouble of evolving their own laboratory schemes.

The fall meeting of the American Electrochemical Society will be again held at Niagara Falls, from September 17 to 19. For the year 1904 it is intended to hold meetings at St. Louis, Mo., and Washington, D. C.

ALTERNATING CURRENT RECORDING WATTMETERS.

The adjoining illustrations show the latest form (Model G) of magnetic suspension wattmeters for alternating current circuits, as made by the Stanley Instrument Co., Great Barrington, Mass.

The Model G, Stanley Magnetic Suspension Meter was offered first in the smaller capacities of 15 and 25 amperes; consistent, constant work in designing has obtained the result that meters in the Model G size and form are now manufactured, offered, and in use for both primary and secondary service from 110 volts to 12,000 volts, for capacities from 10 amperes to 10,000 amperes, and for frequencies from 25 to 133 cycles.

The Model G meter differs from its predecessor, the Model D meter, only in the size and weight. The Model G is but 9¼ inches long, 8¼ inches wide and 6 inches deep, and weighs only 17½ pounds.

Fig. 1 is a front view of the supporting frame, showing brake magnets, dial, etc.; Fig. 2 is a back view of the supporting frame, showing suspension magnets, rotating parts,

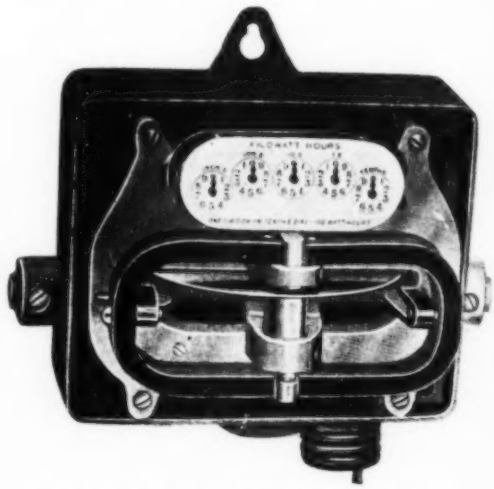


FIG. 1.—STANLEY RECORDING WATTMETER.

dial and train connection; Fig. 3 shows the magnetic suspension elements and the rotating parts floated in air.

The magnetic suspension elements consist of the permanent magnet Y, and the steel plugs or pole bushings, A and B. The rotating parts floated in air are the aluminium disc and the soft steel vertical shaft, called suspension core, to which the disc is rigidly secured. The lower end of the suspension core is flanged larger, while the upper end is turned smaller in diameter than the body of the core.

The flanged lower end of the suspension core is in a cup formed in the lower pole bushing B; the upper end of the suspension core, when in magnetic suspension, is just inside of a recess in the upper pole bushing A. The difference in diameters between the flange of the suspension core and the cup in the lower pole bushing B, as also between the upper end of suspension core and the recess in the upper pole bushing A, is such that there is a predetermined space all around the flange in pole bushing B, and all around the upper end of core in pole bushing A.

When the suspension magnet is not in place the flanged end of the suspension core due to gravitation will naturally rest on the surface of the cup in pole bushing B, but, due to difference in diameters, it will not touch the circumference of the cup at any point, there being an air space between the periphery of the flange and the circumference of cup. When the suspension magnet is not in place and when the

lower end of suspension core rests on the surface of the cup in pole bushing B, the upper end of the core will be slightly below the lower edge of the upper pole bushing A.

Magnetism passes between the ends of the magnetized plugs (pole bushings A and B) attracts the steel suspension core, with the disc attached, in an upward direction, lifting the flanged lower end of the suspension core from contact with the surface of the cup in the lower pole bushing B and carries the upper end of the suspension core into the recess in the upper pole bushing A.

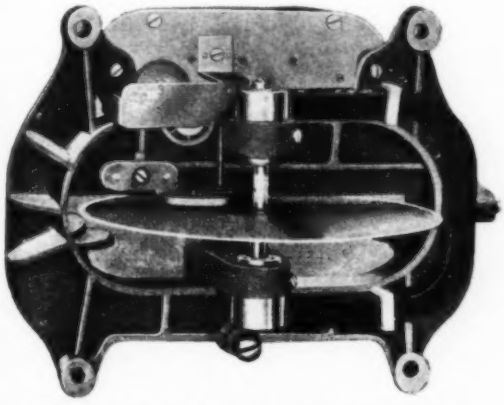


FIG. 2.—STANLEY RECORDING WATTMETER.

By the laws of magnetism, the magnetic field, into which the suspension core with its attached disc is thus attracted, acts uniformly upon the suspension core, holding the rotating parts in a predetermined definite position in space, free from mechanical support or contact of any kind. They float in air.

It is self-evident that in such construction there cannot be any friction due to mechanical rubbing contact. There cannot ever be any increase of friction due to such contact; consequently with magnetic suspension the original frictionless condition of the floated rotating parts must be permanent frictionless condition.

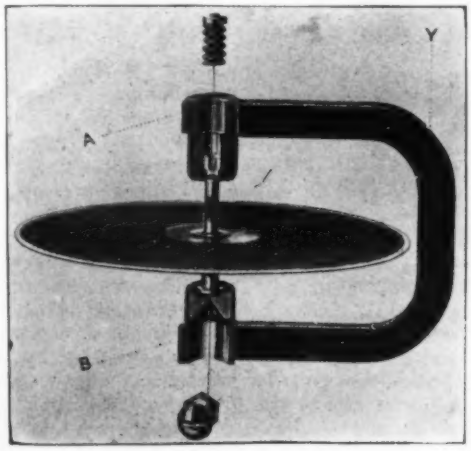


FIG. 3.—MAGNETIC SUSPENSION.

In meters having the bearings of the rotating parts in mechanical rubbing contact, friction and wear and increase of such friction and loss of energy is inevitable by reason of such rubbing contact. Polished diamonds, sapphires and other hard and precious stones and jewels, as well as polished hardened steel and metals, are all shaped and polished by the wear of rubbing contact. Wear means friction, and the greater the wear the greater the friction.

The second cause of great friction and of constant great increase of friction and loss of revenue from unrecorded consumed energy, necessarily inherent in meters having rotating parts in mechanical contact (that of the pounding effect of the alternating current on the bearings and shaft ends) is necessarily absent from the Stanley magnetic suspension watt meters.

It is manifest that, as the magnetically suspended rotating parts do not touch any other metallic or mineral parts, but simply float in the air without mechanical contact, it does not matter how violent may be the pounding or hammering effect of the alternating current, there can be no injury to the rotating parts or air bearings.

OPENING OF THE EMPLOYEES' CLUB ROOMS AT THE WORKS OF THE WESTON ELECTRICAL INSTRUMENT CO., NEWARK, N. J.

On the evening of the 22d of May the directors of the Weston Electrical Instrument Co., Waverly Park, Newark, N. J., turned over to their employees the elegant club rooms recently constructed for them. The occasion was commemorated by a large inauguration reception and ball, to which each employee and a friend were invited, also a large number of the friends of the directors and all the prominent city officials of Newark, including the Mayor, also the Governor of the State.

Over a thousand guests and members of the club were in attendance and the affair was a success in every particular, and reflected a great credit on the various committees in charge. The club rooms throughout were decorated with masses of bunting, flowers and palms, with numerous incandescent lights festooned gracefully from column to column and hidden among the decorations.

A series of sketches by local talent began the evening entertainment. Following this Mr. Edward Weston, the president of the company, made a presentation address, in which he explained the roads along the employer and employee progress, and outlined the directors' ideas of how the interests of both could be best served. He pointed out that without complete understanding of each other's position no measure of successful co-operation could be obtained, and closed by asking for submission of ideas at any time which would tend to benefit the employees, assuring them that any plan presented that was at all feasible would have the company's earnest attention.

Mr. A. O. Benecke responded for the employees, thanking the company, and stated that the employees considered that a new era had dawned, in which their welfare was the predominant feature. In testimony of this, a huge loving cup was presented to Mr. Weston by the employees.

Mr. Weston in responding to the gift showed how greatly he appreciated the feeling of regard his employees extended toward him, and assured them that no business of the magnitude of the Weston Co. could achieve success without being able to repose confidence in every employee, and especially in the lieutenants of the business. He briefly reviewed this country's present prosperity, due to manufacturers, and touched on labor troubles and their disastrous effects.

The result of this employees club will be watched with interest by manufacturers generally, as its success seems assured.

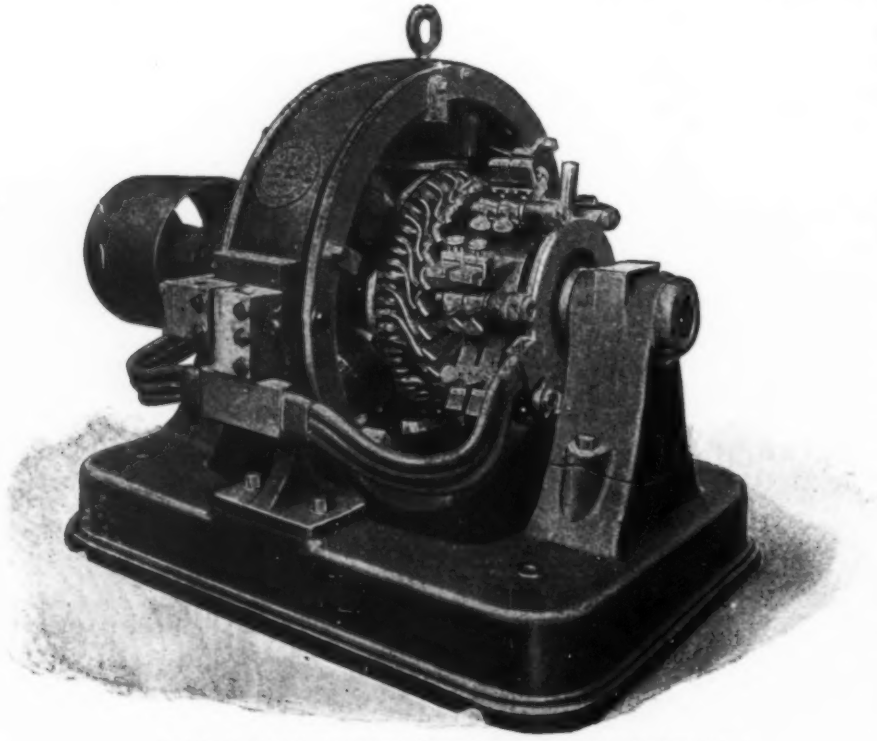
Before turning the apartments over to its employees the Weston Electrical Instrument Co. carefully considered every detail. They have placed the entire government, including the restaurant, in the employees' hands, and, moreover, given them all the furnishings and the benefit of the company's financial backing.

If any fault is found in any department the blame will be centered on the committee in charge, and in no manner can any trouble be construed into a company affair.

A feature of the restaurant is the foremen's dining-room, in which the president will dine with the heads of the various departments, and as all are seated at one large table, it is expected that any foreman will be able to discuss and obtain advice on any problem he desires. An ideal kitchen and ice manufacturing plant has also been installed, and there is a swimming tank over 130 feet long fitted up in the most sanitary fashion.

NEW MULTI-POLAR DYNAMO.

The advantages of compound winding in multi-polar dynamo electric machines have been accomplished by the Hanson & Van Winkle Co., of Newark, N. J., in a most satisfactory manner, and this construction has been adopted on nearly all of their dynamo electric machines, maintaining the simplicity of construction and comparatively few parts that characterize their well-known bi-polar dynamos. The economy of weight by the substitution of special steel for the field and other parts of these machines, and the absence of heat, owing to the perfect ventilation when running at their full-rated capacity, is all that may be desired.



HANSON & VAN WINKLE COMPOUND MULTIPOLAR DYNAMO.

The machines are self-exciting and will maintain full-rated capacity without variation from full load to no load. For use in operating a number of tanks in series they are especially adapted. This applies equally to a plating room where a number of tanks contain different solutions of varying densities, or a number of solutions require a difference in voltage for the successful production of work. When, for instance, a tank is emptied the voltage of the remaining tanks is not disturbed. The machine is automatically self-regulating. The Hanson & Van Winkle Co. are building these dynamos from 1,000 amperes, 5 to 10 volts, to any required size, enabling the operator to vary the voltage at will.

A careful test of one of the 2,000-ampere, 6-volt dynamos made by the Hanson & Van Winkle Co., and in use in a large New York establishment, gave the following results. The dimensions are: 30¼" wide, 40½" long, 32⅛" high. A working test at full load showed a commercial efficiency of 80 per cent., and an electrical efficiency of 93 per cent. The temperature rise over external atmosphere, after eight hours' run, was, for the armature, 40° F., for the commutator, 35° F.

STERILIZATION OF WATER BY OZONE.

In various European cities the method of sterilizing water by ozone has been introduced on a commercial scale. In our issue of September, 1902 (page 31), we noticed the use of the Vosmaer-Lebret system in two waterworks in Holland, and in our Janury issue (page 179) we gave an illustrated description of the method of sterilizing water by ozone in use in two municipal waterworks in Germany; these two plants were installed by the Siemens & Halske Co., of Berlin. These large installations, which are operated in connection with waterworks for a whole town, are of more recent date. Smaller house installations for sterilizing the water used in a single household were installed several years ago by the Siemens & Halske Co. in Hamburg, during an epidemic of cholera morbus, and proved quite successful. That water may be sterilized by ozone to any degree desired, has been proven by very careful tests made by numerous physicians and bacteriologists. The only question — and one which can be definitely settled only by practice on a commercial scale —is that of the cost of the process.

The method of sterilization of water by ozone has not yet been introduced on any large scale in the United States, although there should be a promising field for such processes in our cities, provided the cost is not prohibitive. As is well known, the ozone is made from atmospheric air, by passing electric discharges through the air. The ozone process therefore belongs to the same general class of electrochemical processes of which the process of fixation of nitrogen from the air, used by the Atmospheric Products Co., is another, and probably the most famous, example.

We are informed that very recently a test was made by Mr. Otto, a Frenchman, at the plant of the Atmospheric Products Co. at Niagara Falls in the presence of officials of the Board of Health of various cities. In the ozonizing apparatus a voltage of 50,000 is said to have been applied (against 8,000 in the Siemens & Halske installation in Paderborn). The ozone thus produced was conducted through two pipes to the water-sterilizing tower, which is partly filled with rock, one pipe entering the tower at the top, the other at the bottom. The water, flowing through the sterilizing tower downwards, is purified by its contact with the two ozone streams. It is claimed that 30 to 40 horse-power are sufficient to sterilize 6,000 tons of water per day.

PERSONAL.

MR. DAVID H. BROWNE, chief chemist of the Canadian Copper Co., is at present located at the New Brighton works of the Orford Copper Co.

DR. ROSSITER W. RAYMOND, the well-known secretary of the American Institute of Mining Engineers, has recently returned from a five-months' European trip.

MR. FRANK J. BUCK, of Denver, Col., has been appointed consulting engineer for the San Miguel Copper Co., which will use Mr. Buck's electrolytic copper process.

MR. E. M. ROGERS, who for a number of years was manager of the Aspen Mine, Aspen, Col., and later manager of the Guggenheims' interests at the same place, has recently opened an office as a consulting mining engineer in New York City.

DR. L. A. PARSONS, of Johns Hopkins University, has been appointed assistant professor in physics at the University of Utah. At the recent New York meeting of the American Electrochemical Society Dr. Parsons presented a paper on ions and electrons.

MR. WOOLSEY MCA. JOHNSON, formerly electrometallurgist of the Orford Copper Co., is at present a consulting metallurgist. His headquarters are in Hartford, Conn. Mr. Johnson will either open an office in New York in the near future, or connect himself with a copper producer in the extreme West.

MR. A. B. FRENZEL, of Denver, Col., who recently offered a prize to the American Electrochemical Society for the best research on rare metals, has just completed an investigation of the rare mineral resources of the San Juan Mountains in Colorado. He intends to visit now Arizona for the same purpose.

The marriage is announced of Prof. C. F. BURGESS, of the University of Wisconsin, with Miss IDA JACKSON, daughter of Mr. Charles H. Jackson, of Madison, Wis. Prof. Burgess has a host of friends among the electrochemical fraternity of this country, being known not only by leaders in the art from his work in the university, but to a larger public by his admirable papers and writings.

UNIVERSITY NOTES.

MICHIGAN COLLEGE OF MINES.—A bill has been passed by the Legislature of Michigan, appropriating $171,900 for the Michigan College of Mines at Houghton for the biennium beginning July 1 next. The most important item of this appropriation is that of $45,000 for the construction of a metallurgical laboratory. Electrometallurgy will receive special attention. It is intended to install furnaces of larger capacity than is usual in college laboratories. There is also an appropriation of $9,000 for extending the equipment of the department of mining engineering, which now occupies its new building erected last year, and an appropriation of $4,000 for completing the equipment of the chemistry building, also erected last year.

COLUMBIA UNIVERSITY has conferred the degree of Doctor of Science on Dr. J. J. Thomson, of Cambridge, and on Mr. Peter Cooper Hewitt, the inventor of the Cooper Hewitt lamp and rectifier.

UNIVERSITY OF WISCONSIN.—We have received the catalogue of the University of Wisconsin for 1902-3. The total number of students was 2,870. There is a course in theoretical electrochemistry, with laboratory work in electrochemical measurements supplementing the lectures; also a course in thermal chemistry; a special laboratory course in physical chemistry; lectures on advanced physical chemistry; research work in physical chemistry; seminary in physical chemistry; all these courses are held by Prof. L. Kahlenberg. The course on applied electrochemistry and electrometallurgy, held by Prof. C. F. Burgess, comprises class-room and laboratory instruction in the laws, principles and theories involved in electrolytic phenomena; class-room and laboratory instruction in the industrial applications of electrochemistry; laboratory work; instruction in the electrolytic treatment of metal surfaces; instruction in chemical machinery and appliances. Bulletin No. 65 describes the summer school for artisans under the direction of the College of Engineering, the session beginning July 6 and ending August 14; among the subjects taught in the summer school are courses in electric batteries and in electroplating and electrotyping. In Bulletin No. 68 an illustrated description of the College of Mechanics and Engineering is given, with reviews of the different courses.

WORCESTER POLYTECHNIC INSTITUTE.—The programme of the commencement week, 1903, was as follows: June 8 beginning of the entrance examinations; June 9, annual commencement lecture before the Washburn Engineering Society, given in the Electrical Engineering Lecture Room, Salisbury Laboratories, by Prof. H. B. Smith, on the "Relation of the Electrical Engineer to Modern Social and Industrial Progress," followed by the president's reception to the alumni and senior class. June 11, graduating exercises, commencement address by Superintendent O. H. Tittmann of the U. S. Coast and Geodetic Survey, on "The Work of the United States Coast and Geodetic Suvey;" afterwards the alumni dinner, at the Institute, followed by the annual meeting of the Alumni Association.

INDUSTRIAL NOTES

MR. GEORGE T. EYANSON, of Philadelphia, trading as George T. Eyanson & Co., has sold his interest in the manufacturing plant to The George T. Eyanson Co., Inc.

We have received from the HERBENE PHARMACAL CO. Scientific Laboratories, of New York (Mr. Alois von Isakovics, president), a catalogue of Twentieth Century Raw Materials for perfumers, soapmakers and manufacturers of toilet preparations, creams, etc. The catalogue contains an illustrated alphabetical wholesale price list of the various Herbene synthetic perfume materials.

The F. W. BRAUN CO., of Los Angeles, Cal., have sent us their catalogue of modern labor-saving appliances for assayers and chemists. The pamphlet contains illustrated descriptions of a great many different types of crushers and pulverizers, ore samplers, hydrocarbon burners, crucible furnaces, melting furnaces, muffle furnaces, combination furnaces, coke, coal or charcoal furnaces, improved scorifier tongs, hydrocarbon blowpipe outfits, cupel machines. The various types of apparatus are illustrated.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO. have issued a neat and fully illustrated pamphlet on Electricity in Mining, which will be sent to any one interested in this subject, upon request. After some introductory on the economy of the use of electric power in mining and metallurgical plants, the applications to haulage, hoisting, driving pumps and air compressors, fans and blowers, drills and coal cutters, machine shop tools, etc, and to placer mining are discussed, and numerous machines and apparatus made by the Westinghouse Co for these purposes are illustrated.

DIGEST OF U. S. PATENTS PRIOR TO JULY, 1902.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

BLEACHING AND DISINFECTING LIQUIDS.

(*Continued from page 368.*)

11,244. June 7, 1892. A. E. Woolf, New York, N. Y. Same as 471,454.

560,411. May 19, 1896. Carl Kellner, Vienna, Austria-Hungary.

Bleaches fibrous material by alternately subjecting it to the action of chlorine and an alkali, produced by electrolyzing an alkali chloride. The electrolytic cell has a cover with depending ribs, between which hand the electrodes of alternate

polarity. These electrodes, of carbon, zinc or platinum, have an increased thickness below the ribs to bring their faces close together. The cell has a false bottom of foraminous or filtering material, through which the alkali is withdrawn to one of the bleaching tanks. The chlorine is forced into the second bleaching tank. Each of these tanks consists of three concentric vessels, with intermediate communicating spaces through which the solution is circulated. The tanks have bottoms of porous earthenware, to retain solid matter carried over by the chlorine, and filter outlets, to prevent fibrous material being carried back to the electrolytic cell. The electric current may be reversed in the cell, thus carrying chlorine to the alkali tank and vice versa.

565,706. August 11, 1896. B. S. Summers and C. O. Boring, Chicago, Illinois.

Removes the gum from ramie, jute, hemp, flax, etc., by placing them in the anode compartment of a cell having a diaphragm, the electrolyte consisting of a solution of sodium or potassium chloride or cryolite. The fibre may be supported on a perforated partition, above the platinum anode, or rest directly upon a flat horizontal anode. May immerse the fibre in caustic soda before placing in the cell.

569,173. October 13, 1896. H. R. Cassel, New York, N. Y.

Electrolyses a sodium chloride solution or sea water, and delivers the hypochlorite by a pipe system to places to be disinfected. May add water to dilute the product to the desired strength.

569,680. October 20, 1896. B. S. and L. L. Summers, Chicago, Illinois.

Similar to 565,706. Removes gum from ramie fibre, etc., by placing it in the anode compartment of an electrolytic cell having a diaphragm. Electrolyte, sodium hydrate containing sodium or potassium fluoride or cryolite. Fibre supported above or placed directly upon anode. May subject the ramie to the action of a sodium hydrate solution, containing a small amount of flouride, before treating it in the cell.

575,645. January 19, 1897. Eugene Hermite, Paris, France.

Electrolyzes a magnesium chloride solution, which may contain sodium chloride, or sea water. Cathode, a series of zinc discs cast in one piece with a horizontal shaft, strengthened by a central iron rod. Four anodes depend between each pair of cathodes. Each anode consists of a tube of platinum cloth, supported on a central non-conducting core, and sealed at the upper end into an insulating tube through which passes the conductor, a copper tube, the lower end of which is slotted and clamped on the upper end of the platinum. The electrolyte is delivered into the lower portion of the cell by a perforated pipe; the electrolyzed solution overflows into a gutter surrounding the upper edge of the cell.

579,236. March 23, 1897. Carl Kellner, Vienna, Austria-Hungary.

Bleaches a strip of cloth by passing it between feed rolls revolving in a tank containing a sodium chloride solution, thence between squeezing rolls, and finally into and out of the cell, beneath a revolving cylindrical anode. The cathode is a concave plate, beneath the anode. A perforated partition is interposed between the electrodes. First modification: A strip of cloth depends into the electrolyte between successive pairs of horizontal, parallel rollers, journaled above the vessel, the end ones serving as anode and cathode. The current follows the wetted cloth. Second modification: The strip of cloth passes between and in contact with horizontal, parallel conducting rollers, journaled above the vessel, each acting as a bipolar electrode; the wetted strip of cloth depends into the electrolyte, between successive groups of rollers. Third modification: Loose fibre is passed repeatedly between revolving cylindrical electrodes in the electrolytic cell, being returned from the bottom of the cell to a hopper above the electrodes by a conveyor.

580,919. April 20, 1897. A. E. Woolf, New York, N. Y.

Feeds sea water upward between alternate vertical anodes of platinum and cathodes of carbon and injects the product, through a perforated pipe, into a stream or sewer to be disinfected.

581,052. April 20, 1897. A. E. Woolf, New York, N. Y.

Passes a saline electrolyte upward between vertical platinum anodes and carbon cathodes. The product overflows into a tank which surrounds the cell and is delivered to a bleaching tank containing revolving arms. The spent bleaching liquor is withdrawn, strained and again electrolyzed.

589,959. July 6, 1897. Carl Kellner Vienna, Austria-Hungary.

Electrolyzes salt solutions in the bleaching vessel, which may be a rag engine. Bipolar electrodes of sheet copper, "tombac" or phosphor-bronze, coated on one side with platinum and on the other side with mercury; or of carbon. The electrodes may be covered with asbestos or glass-wool cloth, and are spaced apart by glass sleeves on hard rubber rods passing through the electrodes. May pass a strip of cloth successively between the electrodes and over and under rollers.

588,084. August 10,1897. G. H. Pond, Ashburnham, Mass.

Removes silica from straw by packing it in the cathode compartment of an electrolytic cell, a temporary grating being interposed between the straw and the cathode to facilitate packing. A central pipe extends through the packed straw and serves to withdraw the caustic soda from the lower part and again spray it upon the top of the straw, through a perforated distributor. Steam is introduced into the cell to raise the solution to the boiling point. The packing of the straw largely prevents chlorine from penetrating it.

588. August 10, 1897. G. H. Pond, Ashburnham, Mass.

Similar to 588,084. Straw is packed in a central compartment, separated from the anode and cathode compartments by removable gratings which are withdrawn after packing. Gates close passages between the central compartment and the anode and cathode compartments. The solution which is circulated through the straw may thus be either caustic soda, chlorine water or hypochlorite.

616,139. December 20, 1898. G. H. Pond, Ashburnham, Mass.

Cell has a vertical, concentric central chamber, with openings above and below through which the solution is circulated by a screw. Half fills cell with milk of lime, and then fills with sodium chloride solution. Pairs of carbon electrodes of opposite polarity are hung in the outer space.

616,988, January 3, 1899. B. S. Summers, Chicago, Illinois.

Removes gum from ramie and other fibres by first subjecting them to an alkali hydrate and then placing them in the anode compartment of the cell, containing a solution of sodium fluoride, 5 parts, and caustic soda, 15 parts, in water, 3,000 parts. Heats the electrolyte by the electrolyzing current.

651,849. June 19, 1900. Max Haas, Aue, Germany.

Cell for production of hypochlorites. Vertical, bipolar carbon electrodes, with direct or oblique perforations which are out of alignment.

655,239. August 7, 1900. T. Jespersen, Neenah, Wisconsin.

Electrolyzes dilute hydrochloric acid. Bleaches with the resulting solution and again electrolyzes. Electrodes may be placed in the beater-engine, the carbon anode lying flat in a recess in the bottom and covered by a screen of wood or brass cloth.

657,012. August 28, 1900. P. Schoop, Wildegg, Switzerland.

Parallel cells, each consisting of a narrow, shallow channel in a slab of glass, marble, porcelain, ebonite, paraffin, etc. A sheet of platinum-iridium foil is notched along one edge and bent into an S, the plain portion lining one cell and serving as cathode and the notched portion depending into an adjacent cell, as anode. Graphite electrodes may be employed. Electrolyte, a solution of sodium chloride, passes successively through different cells.

(*To be continued.*)